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REMARKABLE RAILWAY ACCIDENT.

A REMARKABLE railway accident, attended with fearful loss of life, took place on the Lake Shore Railway, near Ashtabula, Ohio, at 8 P. M., December 29th, 1876. A violent snow storm prevailed at the time. The calamity was occasioned by the sudden breaking down of the iron bridge over the creek near Ashtabula station, while the westward bound express train was crossing the structure.

The train consisted of eleven cars, carrying one hundred and seventy-five passengers, and was drawn by two engines, the Socrates and the Columbia, the former leading. The train had stopped at all stations between Erie and Ashtabula except three, and at the time of the disaster was running slowly. As the first engine was passing over the bridge, the engineer felt the structure suddenly settle down. He was then about two car-lengths from the western end. In an instant he opened wide the throttle, the drawbar connecting the two engines snapped in two by the sudden jerk, and the Socrates shot ahead, while the Columbia fell through the bridge, and turned bottom up. The express, baggage and passenger cars followed, the sleeping-car swinging over to one side, and a moment later catching fire from the stove.

As the engineer of the Socrates, who alone was in a position to see the disaster in all its terrible details, reports, the entire wreck was a mass of flames in two or three minutes. The engineer of the Columbia was thrown head first through the window of his cab, and severely but not dangerously injured. Fed by the fierce wind, the fire made swift progress, and so lighted up the ravine that the neighboring people who had heard the fall hastened to the scene.

The snow finally ceased falling, and a colder wind whistled through the snow-bound ravine. At midnight the fire was smouldering among the ashes and ironwork which it could not burn.

Ashtabula Station was about one-fourth of a mile away. Thither the survivors went as soon as possible, assistance for the injured being rendered by the people of the vicinity and those who went to the scene from the depot. By this means the survivors were lodged in various hotels, when a train with the surgeons of the road on board arrived from Cleveland. Early on the following morning men repaired to the wreck, and began the search for the bodies of those who perished.

But with few exceptions they were either wholly destroyed or burned beyond recognition, except by articles of apparel, jewelry, or the contents of their pockets.

Over fifty persons lost their lives, and nearly as many more were badly injured. The depth of the ravine and creek, spanned by the bridge, was 75 feet, and the cars fell that distance, going through the ice to the bottom.

We give herewith a view of the bridge, from *Frank Leslie's Illustrated Newspaper*. The bridge was a Howe truss, built entirely of iron, at a cost of $75,000, and was eleven years old. It was sixty-nine feet above the water, and had an arch one hundred and fifty feet long in the clear, the whole length of the bridge being one hundred and fifty-seven feet. It had been tested with six locomotives, and at the time of the disaster it was considered in perfect condition.

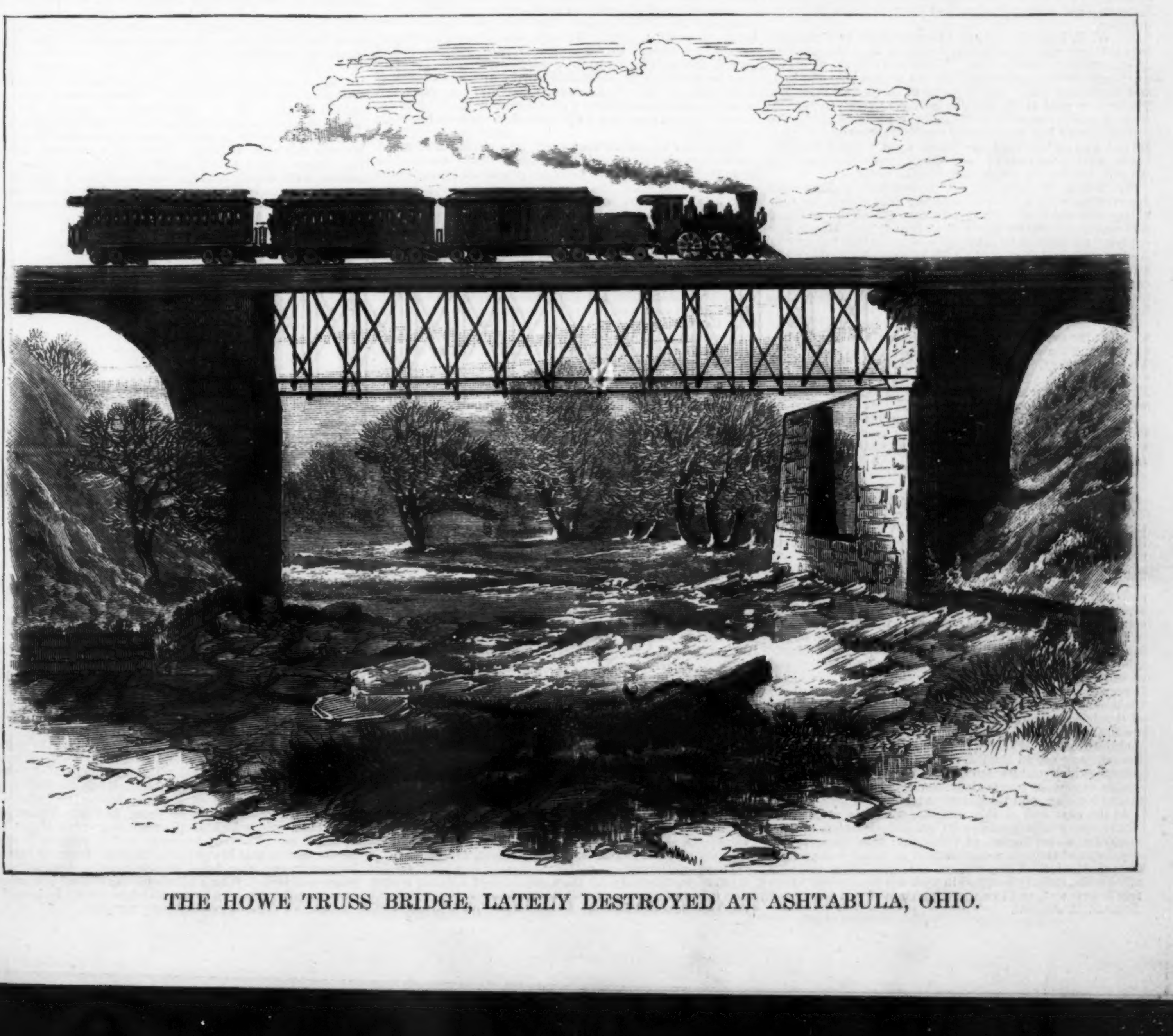
IRON RAILWAY CARS.

AT a recent Car Builders' Monthly Meeting, in this city the subject for consideration was the expediency of substituting iron for wood and steel for iron in the construction of railway cars.

Mr. O. Chanute, the Assistant General Superintendent of the Erie Railway, was introduced to the meeting, and delivered an address in accordance with previous invitation. He said that the substitution of metal for wood as a material for cars would doubtless involve some changes in design, and on this account it might be well to consider how the present style and dimensions of wooden cars have come to be adopted.

As an illustration, he referred to the experience of Mr. Albert Fink upon the Louisville and Nashville Railroad, who, as long ago as 1863, took considerable pains to design as good a freight car as could be made as a standard for the road. This car weighed about 18,000 pounds and carried 10 tons. Strict orders were given that all cars built by the road shops should conform to this model. Some seven or eight years afterwards, however, Mr. Fink was compelled by the increase of business to get some cars built at a contract shop, and which were of course to be according to the standard used by the road. A new car just finished was directed to be sent to the manufacturers as a sample, but, before sending it, it was run upon the scales, and to his surprise and disgust was found to weigh 8,000 pounds more than the original standard. Little by little the various parts had been strengthened and the weight increased; and this showed pretty clearly how cars by the exigencies of traffic have gradually, within a period of 25 years, grown from three or four tons to ten or twelve. The platform or floor structure, consisting of parallel sills without any bracing whatever, is designed merely to carry the superincumbent load, without taking into account the strains to which it is subjected when it goes off the track or in the making up of trains, and which really destroy the car. In the attempts hitherto made in this country to use iron as a material for cars, the methods of wood framing had been adhered to. The parts had been subdivided and multiplied so that in collisions they have been torn to pieces or so badly twisted that they could not be straightened, or they have decayed from rust more rapidly than timber would have done from other causes. Instead of concentrating the weight upon as few parts as possible, as in bridge construction, the contrary practice has prevailed. Our iron bridges, in proportion to their weight, were considerably stronger than iron bridges in Europe, and it was doubtful whether iron cars would prove a success until their framing was made to conform more to the principles recognized in the building of bridges.

Mr. Chanute exhibited a drawing of a European iron car, showing its plan of construction, which he would leave at the rooms for inspection. It was in his opinion about the best of the European iron cars. These cars were built upon



THE HOWE TRUSS BRIDGE, LATELY DESTROYED AT ASHTABULA, OHIO.

different principles from those in this country. They not only weighed considerably less than ours, but it cost only about half as much to keep them in repair, and the estimate of their life was very much greater. There were but few iron cars in England; in France half the cars were of iron, and in Germany nearly all of them. The weight of the German box car, according to the figures taken from the side of one of them, is 15,984 lbs., and the allowed load 22,047 lbs. The flat cars weigh 13,117, and gondolas 13,448 lbs., with the same allowed load. The cost of repairs was stated at ½ cent per mile run, and the life thirty years. The principles which underlie the construction of European cars are these: the iron used is concentrated into as few parts as possible. There are only two sills, and these are made to do all the work. The platform or floor is made sufficiently strong to carry the load, and take all the shocks and strains which occur in practice. Braces are inserted to meet these strains. Instead of merely parallel sills, they are braced diagonally. The box part or superstructure is intended only as a shelter, no dependence being placed upon it to strengthen the car. The whole of it may be sheared off in an accident without impairing the strength of the frame. So little, indeed, is thought of the box part, that much of the freight is carried upon gondola cars with no covering but tarpaulins, and with a saving in loading and unloading of about half the cost.

These details referred to 4-wheel cars exclusively. It was not practicable to go back to these in this country, as we had made a very material improvement in the introduction of the truck. The question was whether we could not adopt European principles in our construction. We have eight wheels to carry a load instead of four, and the point is to design a car for these eight wheels that will carry an increased load. In order to illustrate his meaning, Mr. Chanute submitted some designs showing how the European method might be applied to our 8-wheel cars. One advantage would be to dispense with the bolster at present in use on our wooden cars, and possibly to drop the body from five to seven inches nearer the truck. A larger wheel could also be used. With respect to the substitution of steel for iron, he would say that our knowledge of the properties of steel was too imperfect to enable us to determine exactly in what way it could be employed most economically in the construction of cars. It was better to direct our efforts first to the use of iron instead of wood. The use of steel will follow in due time as a matter of course.

Mr. M. N. Forney remarked that many engineers and mechanics acted on the principle that nineteen new things out of every twenty were good for nothing. In reference to the use of iron cars, it was simply a question of time. The Baltimore and Ohio road was using iron coal cars that were built twenty years ago when wood was a good deal cheaper than it is now and iron much dearer. If these cars were profitable then, they ought to be much more so now. He referred to a very useful invention of Mr. George Richards, the master mechanic of the Boston and Providence road, consisting of two bars of channel iron placed longitudinally upon coal cars to attach the draw-heads to. He alluded to the Chalender truck, with iron transoms, in use on the Burlington and Missouri River road, and to the employment of channel bars and I beams in tender frames, as illustrating the tendency towards the use of iron. The difficulty he thought would be mainly with the fastenings and connections, as had been the case in bridge building.

Mr. W. E. Partridge said that in using iron as a material for cars there must be a radical departure from the methods of constructing wooden ones. Wood and iron could not be used together with advantage, for the reason that the bolts and fastenings could not be adapted to the two materials. The iron, if used at all, must be used constructively, and, if wood is used, it must be incidentally and subordinate. The very nature of iron necessitates a radical difference in plan. He had seen an iron car body placed upon wooden bolsters, but in service the ends of the bolsters turned down and left the iron, leaving the weight all upon the centre.

Mr. Wilson, of Pittsburg, said he had been making some experiments with a view to reducing dead weight, by combining iron and steel. The tensile strength of the combination was much greater than that of iron alone. He was now applying the method to axles, by boring the iron bar and inserting steel, and then welding the two metals together under a heavy hammer. The steel by this process retained all the carbon that it had originally. He believed that a transom made of this combination could be reduced in weight one half and retain the strength of the ordinary size.

Mr. Jones, a representative of the Krupp Steel Works, said that the average mileage of steel wheels in Europe was 500,000, and the wear upon the rails less than by iron wheels. The size of the German solid steel wheel was 38 inches, its weight 884 lbs., and cost $53 gold. The kind sold by the Krupp Works, for use in the United States, was 30 inch, weighing 547 lbs., and costing $44 gold.

Mr. Chanute said if these wheels can make that mileage they would be cheaper than cast iron ones, assuming the average mileage of the latter to be 60,000.—*National Car Builder.*

THE GREAT MEXICAN RAILWAY.

The building of the great railway from Vera Cruz to the City of Mexico was a colossal feat in constructive engineering. The intervening country was superbly beautiful, and crossed at right angles by the great Sierra range, through which is one continued panorama of beauty.

The railway is 267¼ miles long, has 18 lengthy tunnels, and many fine iron bridges. It cost the grand sum of 40,000,000 Mexican dollars, and is undoubtedly the finest constructed railway on the American continent.

The first forty miles are straight, and on a gentle grade, rising slowly from the sea; then for a distance of seventy-five miles it crosses over three distinct ranges of mountains, each of which stands up like a colossal staircase. This section is very crooked. Winding around the numerous canyons in the mountains, the train runs for many miles over the brink of precipices, almost perpendicular, 3,000 feet. The grades are 400 feet per mile, and the ordinary American locomotives find the greatest difficulty in crossing unencumbered. But the company use an English engine—known as the Fairlie patent—which carries ten loaded cars with ease. It is a double engine, or two engines connected, with their heads turned together, and thirty-inch drivers.

At the west end of this division, which is at Boca del Monte, the roadbed reaches its greatest elevation, which is 13,000 feet above the sea at Vera Cruz; from there it gradually declines through a continuation of broad valleys to the City of Mexico. These valleys are from three to twenty miles wide, entirely hemmed in with tall mountains. Every foot is irrigated, and in a thorough state of cultivation.—*St. Louis R. R. Journal.*

ERIE AND NEW YORK CENTRAL.

On the two roads these rates and the expenses have been:

	1876. Erie.	1876. N. Y. Cen.	1875. Erie.	1875. N. Y. Cen.
Per passenger per mile—				
Receipt	2·102 cts.	1·910	2·227 cts.	2·140
Expense	1·854 "	1·090	1·951 "	1·360
Profit	0·248 "	0·820	0·276 "	0·780
Per ton per mile—				
Receipt	1·099 "	1·050	1·209 "	1·270
Expense	0·885 "	0·710	0·949 "	0·900
Profit	0·214 "	0·340	0·260 "	0·370

The Central thus during last year received lower average rates for both passengers and freight than the Erie, but its expenses were so much lower that its profit was more than three times as great per passenger per mile, and 60 per cent. more per ton per mile. The enormous disproportion in passenger expenses may be due partly to a difference in the method of dividing the expenses between freight and passengers; but then if any change is made, what is added to passenger expenses must be taken from freight expenses. It appears to cost the Erie a quarter more than the Central to carry a ton of freight a mile, and the difference is greater this year than ever before. We ventured some years ago to say that something like this would be the inevitable result should the Erie be permitted to remain without those improvements which would make it equal to its rivals. They, we said, were preparing to carry traffic at less expense than formerly, and the result would inevitably be a reduction in rates. Should the Erie not keep pace with them in reducing expenses, which could be done only by expenditures for equivalent improvements, the time would come when a rate which would yield a satisfactory profit to the Pennsylvania and the New York Central would little more than cover the working expenses of the Erie. Evidently that time is now impending. When we wrote, the Erie's expenses per ton per mile were about as low as the New York Central's—sometimes lower; now they are so much higher that a cent per ton per mile leaves the Central two and a half times as great a profit as the Erie can get from that rate. And the end is not yet.—*Railroad Gazette.*

IRON PASSENGER CARS.

The *Compagnie Française de Materiel de Chemins de Fer,* at Ivry, France, is building a special type of carriage for service on the little railway between Bayonne and Biarritz. The designer is M. Carimantroud. The framework is entirely in iron; in spite of their large size the weight of the carriages is relatively small; the panels of the body are made of thin slips of wood, covered on both sides with varnished canvass. There is a covered upper story, and an interior staircase; each carriage is arranged for three classes, and has a goods department and smoking platform as well. The open spaces are as large as possible, to permit good views being taken. Petroleum is used for lighting; the lamps are so arranged as to give light to the interior, and at the same time show the signals. Each carriage accommodates 92 passengers.

HARTNELL'S GOVERNOR.

A governor effectually to control the speed of an engine must possess two qualifications in sensitiveness and power, or a capability of changing its position for slight changes of speed and the ability to make such changes whilst attached to the controlling gear. Without sensitiveness a governor cannot be expected to regulate an engine, but for lack of power, although it may be inherently sensitive, the governor may be held fast or so retarded that a greater variation of speed than that due to its entire range may take place. A weak governor attached to a cut-off gear is liable to be disturbed by such gear, and its proper effect rendered uncertain or abortive.

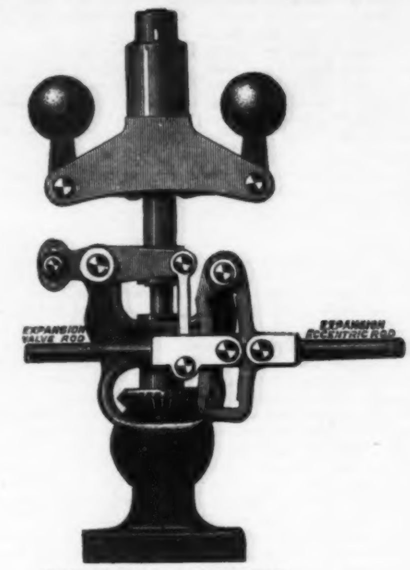
The power a governor may exert, on a reduction of speed, cannot exceed that stored up when the balls are furthest from the spindle. In the ordinary pendulum governor this equals the weights of the balls multiplied by the perpendicular height they are lifted. The higher the ball rises the greater is the power, but the less the sensitiveness, the one quality being obtained at the sacrifice of the other. This defect is common to the majority of gravity governors, and still more to the ordinary forms of spring governors.

Governors, as usually proportioned, so as to be fairly capable of working the ordinary throttle valve, are too weak to control variable expansion gear, unless acting through some intermediate source of power or on some form of trip gear, as in the Corliss engine. To increase their power without inconveniently adding to their bulk, several expedients are resorted to, such as increasing the balls, or adding a weight on the spindle (which increases the power, but in general leaves the inherent sensitiveness unaffected), or the arms are crossed so that the balls rise higher with the same variation of speed. By none of these means can so much power be stored up as by the use of a spring; but such springs, in the more common forms of spring governor, are so attached that a comparatively large variation of speed is required to utilize their force, or else the action must be so limited that they possess no advantage.

The governor illustrated below is intended to meet these requirements, to be compact, light, sensitive, and powerful, and capable of acting promptly on an expansion gear. It was designed by Wilson Hartnell, our engraving showing it as applied to a portable engine by Messrs. Marshall, Sons & Co., of Gainsborough, Eng. In this instance the gear is all attached to the governor stand, so that the whole may form an automatic expansion regulator conveniently adaptable to portable and fixed engines. It consists of two balls fixed on bell crank levers, the other ends of which carry friction wheels which press against the sliding piece on the spindle. The sliding piece is pressed by a powerful spring to resist the centrifugal force. The levers move through an angle of about 50 degrees.

Motion is transmitted to the governor lever shaft by means of a solid ring between a pair of levers, between also a fixed and loose collar on the sliding piece. This lever shaft also carries the lifting lever with its lifting link, for raising and lowering the valve rod in the expansion link which is suspended from the governor stand. The parts are so arranged and proportioned that when the engine has a mean load there is scarcely any slip of the link block. The range of expansion that can be obtained by thus varying the travel of the cut-off valve has been extended from the very beginning until five eighths or two thirds the stroke by the use of multiple ports and a particular adjustment of eccentrics and valves. A sharp cut-off is effected at all points, whilst the full power of the engine is, at any moment, available.

The special advantages of this "automatic regulator" are that it offers great facilities for the application of a strong spring, that it can utilize some two thirds to three fourths of its maximum accumulated force, at the same time the sensitiveness can be varied at pleasure with but little effect on the power. For, since the resultant centrifugal force acts at the centers of the balls, and the force of the spring acts at right angles on the centers of the friction wheels, it follows that if the bell cranks be rectangular the two forces will, for all positions of the cranks, bear a constant ratio. Also, since at a uniform



HARTNELL'S GOVERNOR.

speed the centrifugal force is in proportion to the radius, whilst the resistance of the spring is in proportion to the compression, it follows that whatever be the length or strength of spring, if the initial compression bears the same ratio to the final compression that the minimum radius of ball bears to the maximum, the governor will be isochronous, or will remain in any or all positions at a certain speed. Such an adjustment would be too unstable to govern an engine, but by reducing the initial compression any desired variation of speed may be obtained.

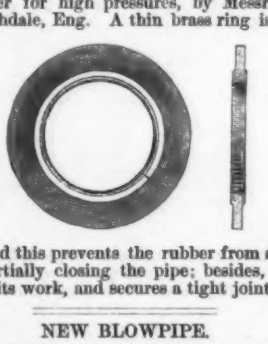
Thus, if the governor illustrated were fitted with a spring that made the maximum and minimum revolutions 290 and 270, by altering the tension of the spring other pairs of revolutions would be found, such as 272, 230, or 281 and 250, or 290, 270, or 299, 290, or 304, 300. It may be observed that if a considerable variation of speed be desired, the governor will be least sensitive when nearly closed, to remedy which the cranks should rather exceed 90 degrees.

The power of a governor about the same size, having a pair of 5 in. balls lifted 2 in., would be 5·7 foot pounds. For the mean speed of 280 the work done by this governor with 3½ in. balls would equal 36 foot pounds, or equal to a pair of 9 in. balls rising 2 in. The mean resistance of the spring would be about 200 lb., equal to an 11 in. ball on the spindle. It is evident that no gravity governor of equal bulk (much less equal weight) could be nearly as efficacious where much resistance had to be overcome. This governor offers also special facilities for the introduction of four or six balls where quicker speeds for higher powers are objectionable.

In larger sizes the power that can be given out by the governor is still more striking. Thus, for a governor designed for a large engine, having a pair of 5½ in. balls on an 8 in. radius, with double springs, the power for a mean of 250 revolutions equals 265 foot pounds, the height from the top of the cap to the bottom of the sliding piece in mean position being only 2 ft. 1 in.—*Engineering.*

ELASTIC WASHERS.

The accompanying engraving illustrates a very neat combination washer for high pressures, by Messrs. Turner, of Spotland, Rochdale, Eng. A thin brass ring is fitted inside



the washer, and this prevents the rubber from squeezing inwards and partially closing the pipe; besides, it keeps the rubber up to its work, and secures a tight joint.

NEW BLOWPIPE.

A novel blowpipe, consisting of a fire chamber connected with an air forcing apparatus, and provided with nozzles of various forms for directing one or more jets of heat and flame, has been designed by Messrs. Dodge and Gushurst, Omaha, Nebraska. The object is to provide a portable blowpipe, the flame of which will have sufficient power to heat objects of considerable size. The fire chamber consists of a cylinder of iron having conical ends. To one of the ends the blast pipe is attached, and to the other a nozzle is attached by screws, so that it may be removed and replaced by nozzles of different forms. There is an aperture in the top of the fire chamber for the introduction of coal, &c. The chamber is lined with a coating of fire clay. Flat, elliptical, or double nozzles, capable of directing the flame on both sides of an object, are used according to circumstances. In use, the chamber is filled with burning charcoal, coke, or other suitable combustible substance, and the blast pipe is connected by a flexible pipe with a blower or bellows. A blast being created, a jet of flame and heated gases issues from the nozzle, which is directed against the object to be operated on. The heat generated in this manner is said to be so intense that heavy irons, like the frame or braces of locomotives or other large objects, may be heated in their places and bent. With a nozzle having several jets arranged in an arc, the tire of a locomotive wheel may be heated and expanded, so that it may be easily removed.

KÖRTING'S LOCOMOTIVE INJECTOR.

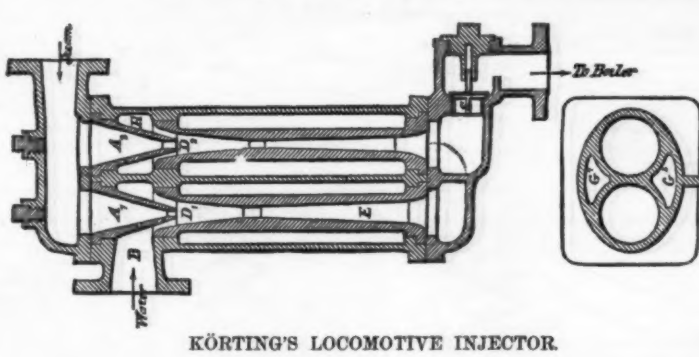
LOCOMOTIVE injectors as hitherto constructed labor under the disadvantage of feeding with cold water only, and they can hardly be relied upon, says *Engineering*, if the temperature of the latter exceeds 104 degrees Fahr. Even then they require the most careful adjustment of the water supply. The reasons for this defect may be traced to the principles upon which the injectors are constructed.

With an injector of correct proportions the certainty of action depends upon the velocity with which the water enters the space where the steam and water combine. In locomotive injectors, to which the water can flow with only a very small pressure, this velocity depends mainly upon the vacuum produced in the condensing nozzle. This vacuum must be kept as high as possible. With *constant* steam pressure and temperature of water, the vacuum obtained is lower when the condensing nozzle is fed with too much or too little water; in the first case because the jet of steam has not sufficient power to impel the water which gives a back pressure; in the second case because the temperature of the mixture is not low enough, and consequently the vacuum is lessened. For these reasons the water supply requires to be very carefully regulated. With *variable* steam pressures and temperatures of the feed water, the vacuum becomes lower with increasing temperature of water, and also with increasing steam pressure, as in both cases the temperature in the condensing space is raised, the maximum of which can be only 212 degrees Fahr. But at this point the certainty of action is *nil*; generally speaking, this temperature should not exceed 194 degrees Fahr. As the increase of temperature with high pressure steam is about 90 degrees Fahr., it follows that the feed water should not be hotter than 104 degrees Fahr. On this account many railways will not allow their drivers to warm the feed water in the tenders, as the reliability of the injectors increases with the coldness of the water, and certainly is of the first importance in railway management. This defect is almost entirely done away with in Körting's universal injector, which works with equal certainty at all pressures. This apparatus consists of two steam jet pumps combined. The second pump or real injector which forces the water into the boiler receives it from the primary or assistant injector under pressure, so that the second pump has only to overcome the difference in pressure existing between that of the boiler and that already overcome by the primary injector.

The required quantity of steam is therefore divided, and only a small portion of it used in the first part of the apparatus. Consequently the increase of temperature is much less than in ordinary injectors; the water entering it may therefore be much warmer without bringing the temperature in the condensing space above 194 degrees Fahr., which is the maximum here as in ordinary injectors. The temperature of the feed water may safely be as high as 158 degrees Fahr. A special feature of this primary injector is that with increased steam pressure it delivers, without regulation, more water at increased pressure to the second part of the apparatus.

The second pump delivers into the boiler the water forced into it by the primary injector. The certainty of action of this second part of the apparatus depends upon the pressure with which it is fed by the assistant injector, and not upon any vacuum. As with increasing steam pressure the velocity of the water entering the second pump is also increased, it follows that with the same temperature of feed water the reliability of this apparatus remains the same under all steam pressures, while with ordinary injectors it decreases as the steam pressure increases. On this account no water regulation is necessary. The temperature in the condensing space does not come in question with the second part of the apparatus; it may, if required, exceed 212 degrees Fahr., and in fact does exceed it, for with feed water of 158 degrees Fahr., and 120 lbs. boiler pressure, the water fed into the boiler is actually 257 degrees Fahr. The apparatus therefore must not be provided with an overflow communicating with the atmosphere, as otherwise the high temperature would cause the formation of steam and an escape of water. The apparatus is started by opening a small cock behind the injector similar to that with which other injectors are provided for letting the water out of the pressure pipe.

The illustration published above shows the Körting universal injector in longitudinal and cross sections. The working steam simultaneously enters the two steam nozzles A_1 and A_2 in the injector. The jet of steam from A_1 draws the requisite water through the pipe B, and forces it through the cone D_1 with corresponding velocity. This velocity is transformed into pressure in the diverging tube E which communicates by means of the chambers G_1 and G_2 (see cross section) with the space H of the second pump. From here the water enters under pressure the condensing space D_2, whence it is forced by the steam issuing from the nozzle A_2 into the boiler through the back pressure valve S. While starting the injector, a cock communicating with space E_1 is opened till water escapes from it, after which it is slowly closed. These universal locomotive injectors are supplied by Messrs. Korting Brothers, of 7 and 17 Lancaster avenue, Manchester.



KÖRTING'S LOCOMOTIVE INJECTOR.

POWER LOOM.

MR. BIGELOW, of Hartford, Conn., was the first to invent the Brussels power loom, about the year 1845, and offered it for sale to the manufacturers of Kidderminster, who refused it. The invention was afterwards purchased by John Crossley & Sons, of Halifax, Eng., for £10,000.

THE RIVER CLYDE.

THE profession of Civil Engineering, as defined by Telford, which definition is incorporated into the Charter of the Institution of Civil Engineers, is "the art of directing the great sources of power in Nature for the use and convenience of man," and there are few more striking examples of what science may do for commerce, or of what man may accomplish by working hand in hand with nature than is the proud position of the River Clyde at the present day, as compared to what it was one hundred years ago, or even as late as the year 1840.

To many of those who attended the recent meeting of the British Association, and who have fresh in their memory the geography of the City of Glasgow, with which must indissolubly be connected the princely hospitality of its inhabitants, it may be interesting to know that the noble river which has made Glasgow the mighty city that it is, from whose shores some of the largest ironclads of our fleet have been launched is a water highway, almost as much the work of man as is the Suez Canal itself.

One hundred years ago the Clyde was little more than a picturesque mountain stream, so shallow, that at a place called Dumbuck Ford, twelve miles below Glasgow Bridge, passengers could traverse it on foot. Now, vessels drawing twenty-three feet of water can ride safely in the heart of the city at low water, and the largest ocean-going steamers can come up the river at all times of the tide.

This wonderful change has been brought about by a succession of engineering operations, in all of which Nature has been coaxed, by artificial means, into doing the largest share of the work; and the operations of man, great as they have been, have been directed solely to assist that work, and to remove obstacles which stood in its way. The names of the engineers under whose directions these improvements have been made, alone show that the highest scientific skill has been brought to bear upon the development of the water-way to the City of Glasgow; for, within the last one hundred years, among the engineers who have been employed by the Clyde trustees, either to carry out improvements, or to prepare reports in connection therewith, will be found the names of Smeaton, Golborne, Watt, Sir John Rennie, Telford, Stevenson, Walker, Scott Russell, and Bateman; but the largest engineering operations have been left for Mr. Deas, the present engineer of the Clyde navigation, to carry out, for since the year 1872 greater progress has been made than during any previous equal period. In that time no less than 1,505 lineal yards of quayage have been added, slip and graving-docks have been constructed, large cranes erected, and very considerable progress towards completion has been made in the celebrated Stobcross Docks, of which we shall speak further on.

The exceptional construction of these docks, necessitated by the local peculiarities of the geological strata, formed the subject of a valuable paper read before the British Association by Mr. James Deas, C. E., under whose directions they are being constructed, and who has recently published a most interesting work upon the Clyde,* illustrated with maps, sections, and tidal diagrams, and from which many of the data contained in this article have been derived, and to which we would refer those of our readers who wish for further investigation.

It is just a hundred and eight years ago since John Golborne, of Chester, visited the Clyde, and made his first report, in which he pointed out that the shores of the river "in most places being much softer than the bottom, the current has operated there, because it could not penetrate the bed of the river, and has by those means gained in breadth what is wanting in depth;" and, he added, "I shall proceed on these principles of assisting nature when she cannot do her own work, by removing the stones and hard gravel from the bottom of the river where it is shallow, and by contracting the channel where it is worn too wide."

Golborne, carrying these principles into practice, erected a number of rubble jetties so as to contract the channel, giving to the stream greater rapidity, and consequently greater scouring power, and by a system of dredging in the deeper shallows, and horse-ploughing in those which were exposed at low water, he loosened the hard crust forming the bed of the river, exposing to the action of the current the softer material below, which was speedily scoured away, and in less than eight years the depth of water at Dumbuck Ford was increased from 2 feet to 14 feet. Golborne was followed by Rennie, who, in 1799, recommended the shortening of some of the jetties, the lengthening of others, and the construction of new ones, so as to direct the channel in its proper course with the least obstruction to the water; and to insure this he recommended building rubble walls from point to point of the jetties, so as to avoid the formation of shoals between them. These suggestions were carried out by the Clyde trustees, and upwards of 200 jetties were thrown out between Glasgow Bridge and Bowling, a distance of eleven miles. During the next forty years improvements continued to be carried on, and the names of Telford and Rennie appear again in connection with them. In 1836 a report of Mr. Walker, the engineer to the navigation at that time, showed that there was a depth of water at the Broomielaw, just below Glasgow Bridge, of 8 feet at low water, and, he adds, that "the river which by artificial means was to be rendered capable of taking craft of thirty to forty tons to Glasgow, has, by what Golborne called 'assisting nature,' been rendered capable of floating vessels nearly ten times the burden." But improvement did not stop here. Since that date the Harbor of Glasgow has been widened by 240 feet, and vessels of 3,000 tons burden can float where at that time stood one of the largest cotton mills in the city.

Some very curious phenomena connected with the tides have resulted from the alterations of the tidal channel produced by these engineering operations. The level of low water in Glasgow Harbor has been getting lower and lower, until it is now no less than 8 feet lower than it was in 1758, and during the last fourteen years there has been a depression of level of over a foot. This has been accompanied during the same period by a corresponding rise in the level of high water at ordinary spring tides. These phenomena are no doubt due to the greater facility with which the tidal wave can pass up and down the river than formerly, its shallow, broken, irregular, and tortuous channel having been straightened and deepened, and obstructions offering resistance to its flow having been removed. The increase of the rapidity of the flow is as remarkable as the increase of the volume of water. In the year 1807 the time of high water was three hours later at Glasgow than at Greenock, thirty years after there was a difference of 1 hour 23 minutes, and at the present time that difference has been reduced to 1 hour and 5 minutes. At Greenock the tide flows for about 6¼ hours and ebbs for about 6 hours, whereas at Glasgow it flows for 5¾ hours and ebbs for 6¾ hours.

In the improvements of the Clyde the one principle followed by all the engineers has been the increasing of the volume of the tidal wave and the prolonging of its flow into the upper reaches of the river. Very little work has been done by the natural freshwater stream, although that is estimated at an average of 48,000 cubic feet per minute, which represents in round numbers over 300 million gallons for every twenty-four hours. This fact demonstrates very forcibly that it is to the tidal ebb and flow that we must look for the conservation of the channels of tidal rivers, rather than to the action of the land-water, which cannot be depended upon for constancy, and its tendency is more often to deposit than to scour.

To keep the channel of the Clyde in order constant dredging all the year round has to be maintained, and under the able administration of the engineer to the navigation this has been brought to a high state of perfection, both in amount of work done and in its very small cost, averaging, as it does, from about one shilling per cubic yard for gravel to 2½d. per cubic yard for sand, and these costs are inclusive of repairs.

Although the trustees already possess the largest steam-dredging fleet in the world, they have lately given to Messrs. Rait & Lindsay, of Glasgow, whose firm has a world-wide reputation for the construction of such plant, an order for four new steam hopper barges, thus bringing the number up to eighteen. These vessels are designed by Mr. Deas, and will measure 150 feet long, 26 feet wide, and 12 feet deep, and each capable of carrying 500 tons of dredged material. They will be fitted with compound high and low pressure engines, which will also be constructed by Messrs. Rait & Lindsay.

Dredging is employed for widening the river as well as for deepening the bed. When a bank has to be cut away the dredger is worked close to it so as to undermine it, and by this means much cost of excavation is saved.

For the removal of boulders, some of which weigh over six tons, diving bells are employed. Last year one bell lifted no less than 656 tons of boulders from the bed of the river. These bells are also employed for removing the *débris* resulting from sub-aqueous blasting operations which are continually going on, both dynamite and gunpowder being employed for the removal of whinstone or trap rock. The charges are contained in tin canisters, which are inserted in holes of 3 inches diameter drilled in the rock, which are afterwards sealed up with Portland cement. They are fired in groups by a voltaic battery on the deck of the diving-bell barge, and the shattered rock is removed by the bells.

To give an idea of the benefits which engineering operations of this kind can confer upon the community, it is interesting to notice that whereas the reports of Smeaton, Telford, and Rennie, showed that the river was navigable only for barges to Glasgow, at the present time the registered export and import tonnage of Glasgow amounts to 2½ million tons, or equal to half the tonnage of London or of Liverpool. Population statistics point to the same result. In 1831 the population of Glasgow numbered 202,000, in 1861 it had risen to 395,000, and it is estimated at the present time at 535,000.

The great increase of the shipping trading into the port of Glasgow has had to be met by the extension of quays and by the construction of docks. The first of these, Kingston Dock, was opened in 1867, giving about 5¼ acres of water-space, but the trustees are now constructing docks at Stobcross which will have an area of over thirty-three acres, and capable of accommodating 1,000,000 tons of shipping. A graving dock, 560 feet long and 72 feet wide, with a depth of water of 22 feet, has also lately been opened.

The Stobcross Docks possess an especial scientific interest from the fact that the quay walls are supported on groups of concrete cylinders, a system of sub-aqueous foundation adopted here for the first time by the Clyde trustees at the recommendation of Mr. J. F. Bateman and Mr. James Deas, and the results have proved so eminently successful that this system is likely to be universally employed for dock foundations in sandy or gravelly soils. During the execution of this work the variety of the geological strata was particularly interesting, ranging as it did from boulder clay of the most tenacious character to the finest and sharpest of sand, much of which was used for the manufacture of glass.

The concrete cylinders are arranged in groups of three together, and are built up of rings formed in movable wooden moulds; they are 27 feet 6 inches in height; made up of eleven rings each, and rest upon iron shoes. When a group of three cylinders is built up to its height, diggers specially designed for the purpose are set to work excavating the sand and gravel from within the cylinders; as this comes away the whole structure disappears into the ground, being helped in its descent by the addition of about 300 tons of cast-iron weights placed on the top. The average rate of sinking is about 1 foot per hour, but as much as 5 feet per hour has occasionally been attained. When the group has been sunk, it is cleaned out by the diggers to the level of the shoe, each cylinder is then filled with Portland cement concrete, and upon this foundation the quay wall is built.—*Nature.*

* "The River Clyde; an Historical Description of the Rise and Progress of the Harbor of Glasgow." By James Deas, M. Inst. C. E. (Glasgow: James Maclehose, 1876.)

WIND AT 153 MILES AN HOUR.

MR. RUSSELL, the government astronomer at Sidney, reports that during a heavy storm of wind which occurred in that part of Australia last September, the wind, in a gust lasting one or two minutes, attained the extraordinary rate of velocity of 153 miles per hour, as ascertained by Robinson's cup anemometer; and that during the twelve minutes, from 12.18 to 12.30 A.M., 22¼ miles of wind passed the Observatory, being at the rate of 112 miles per hour.

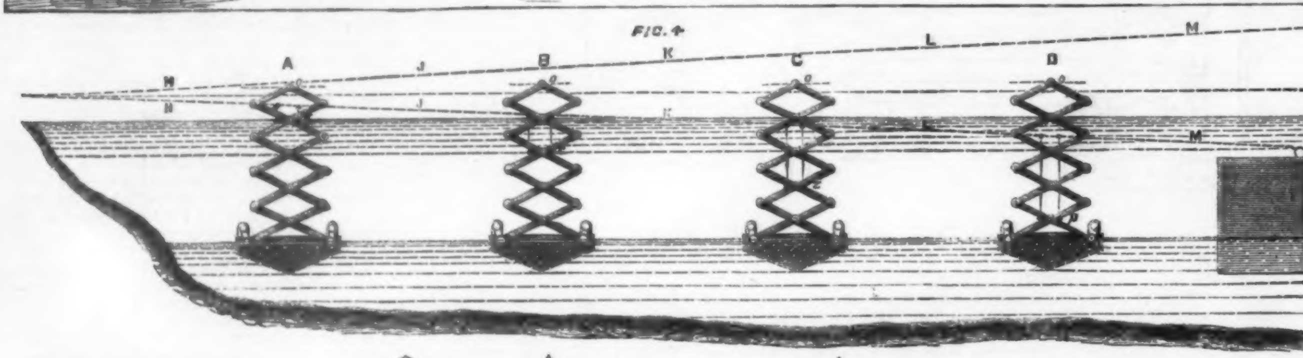
EGERTON'S TIDAL PIER.

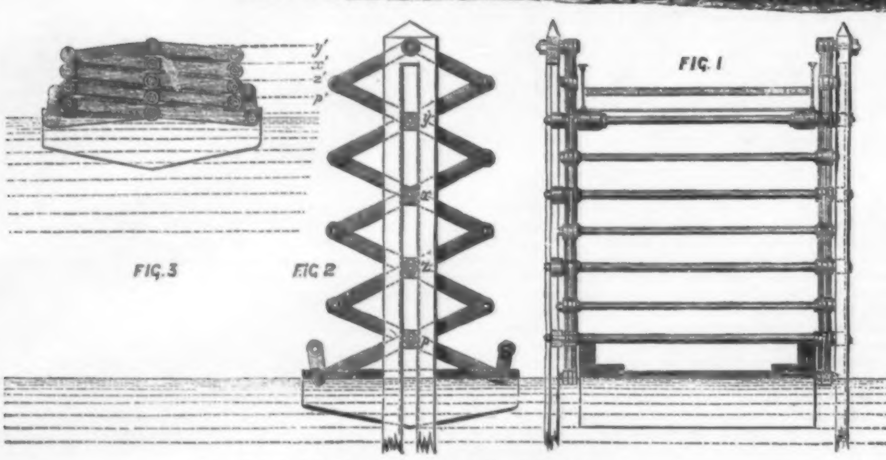
ALL of our readers who have noticed the enormous incline at low tide of the ways joining the shore with the floating stages alongside which the river steamers stop on such rivers as the Thames, where there is a difference of 20 ft. between ordinary high and low water, will have perceived how impossible it would be to employ them for the passage of laden wagons drawn by horses. If, however, the causeway could be made some 400 ft. long, the incline would be so slight that there would be no difficulty for horse wagons to go up and down it. But to construct such a causeway, supported only at the ends, of requisite strength to bear the severe strains of heavy traffic, it would have to be made of such excessive weight that the size of the floating stage which would have to support it would require to be made out of all practical proportion. Mr. Egerton has, however, hit upon the expedient of employing several floating dumbies, situated at intervals of 80 ft. from each other, increasing in size as they get farther from the shore, by which the weight of the bridge may be proportionally borne throughout its whole length, and thus the necessity of a huge girder construction is done away with, and a number of small girder bridges substituted, which can be made considerably lighter in proportion, and yet be quite strong enough to bear the weight required. These separate girder bridges are jointed together, and supported at either end by the several floating dumbies with which they are connected, and in order to keep the roadway perfectly level, so as to form a regular incline, the supports are made to rise and fall through only a proportion of the total rise and fall of the tide, regulated according to the number of divisions and their distance from the land and the landing stage or dumby. For instance, in a length of 400 ft., divided into five parts, with a total rise of the tide of 20 ft. at the first division, A—see Fig. 4—a rise of only 4 ft. will be required; at the second division, B, the rise will have to be 8 ft.; at the third, C, 12 ft.; and at the fourth, D, 16 ft.; while the end dumby, or landing stage, rises through the total rise of the tide, viz., 20 ft. In order to accomplish this, a series of levers is made use of, arranged in the manner shown in the detail sketches, Figs. 1, 2, and 3, and of the form and action of what is commonly known as lazy-tongs. At the first division, A, the two first girders, H and J, are jointed by links or stringers to the point *y;* and at the second division, B, the two girders J and K are jointed to the point *x;* and at the third division, C, the two girders K and L are jointed at their point of contact to the point *z*, and similarly L and M are jointed at *p*. Piles being driven into the bed of the river, which act as guides to the floating dumbies, the lazy-tong systems of levers are jointed to the top of the piles, to which they are severally attached at the points *o, o, o*, and their lower ends being actuated by the floating dumbies, it will be readily seen that, taking the first support as an instance, while the dumby at the bottom is rising through the distance 20 ft., equal to the rise of the tide, the point *y* is only moving through the distance *y y'*—see Figs. 2 and 3—viz., 4 ft. At the next support, in like manner, the point *x* moves through the distance *x x'*, or 8 ft., and so on in every case the junction of the girders are moved through proportionate distances; and it will be further seen that, as these points *y, x, z*, and *p* will always form a straight line at all times with each other, it is not necessary that the pier should be made of separate girders, but the whole length may be made of one piece of sufficient section to bear the weight and load between the supports. It will also be seen that as these supports approach the shore, the weight upon them will diminish, and the floating dumbies can therefore be reduced in equal proportion.

The levers are arranged in pairs, as shown in Fig. 1, on each side of the roadway, and tie rods from the joints of one on the one side connect them to those on the other side of the roadway, thus forming a system of diagonal tying, and as the central joints move in a perfectly vertical line, a guide is formed which prevents any lateral strain. The pier, of course, being constantly in motion, the formation of rust at the joints will be to a great extent prevented; but if it be thought necessary, the further precaution may be taken of bushing the holes and sheathing the pins with gun-metal. The whole of the working parts being above the water line, they can at all times be easily got at for repairs. The diagram, Fig. 4, is drawn merely to show the action of a pier forming a gradient, descending at low water, and ascending at high water, the pier being perfectly level at half-tide; but it is in every respect similar in action to a pier constructed so as to form any incline downward as the tide recedes, and to be level at high water. When, however, it is thus made, it is not necessary to support it as shown in the drawings, as it takes its bearings directly on the levers.

Although it would be impossible to put such a pier, 400 ft. long, out into the Thames, it is evident that there would be nothing to prevent its being placed parallel to the bank, and at such a distance from it as not to interfere with barges and shipping going alongside the wharves, in the same manner as the present landing stages of the river steamers are placed; and it is manifest that a great saving in the cost of transporting goods across the Thames, the Mersey, and other tidal rivers would be made by placing such piers on either side of these rivers at different points, and connecting them by means of suitable ferry steamers capable of carrying a certain number of loaded carts and wagons, and by this means the relief to the present enormous traffic in the city of London, which is so much needed, would thus be insured.

It is evident that such a pier could be readily arranged so as to suit any spot where it may be required, for it can be placed either at right angles to the shore, parallel to it, or at any desired angle, and it can be constructed with any number of supports, with one or any number of pontoons, with one or any number of girders, and of any strength which may be considered necessary.—*The Engineer.*





EGERTON'S TIDAL PIER.

THE PROPOSED NEW BRIDGE, LONDON.

A MEETING of the Court of Common Council, London, was lately held, the Lord Mayor presiding. Having very carefully considered the various returns, and after a very careful inspection of the localities, it appeared to them that the most eligible site for a bridge over or a subway under the Thames would be that approached from Little Tower-hill and Irongate Stairs on the north side, and from Horsleydown S airs on the south side of the river. They then proceeded to consider the references upon the designs submitted by the following persons, namely: 1, Mr. Frederick Barnett, who submitted plans for a low level bridge, the center of which would consist of two swing bridges on turn tables in the center, one at each end of a pier, leaving waterway on each side for large vessels when the swings were open; 2, Mr. G. Barclay Bruce, Jr., who sent in plans and a model for a roll bridge, the bridge or platform moving over rollers from shore to shore by steam power [see engraving, SUPPLEMENT No. 20]; 3, Mr. Sidingham Duer, who submitted plans for a high level bridge with hydraulic lifts at each end; 4, Mr. T. Claxton Fidler, who sent in plans for a high level suspension bridge, approached on the north side by a gradient of 1 in 40 from the end of the Minories, and on the south side round a spiral approach of about 400 feet in diameter; 5, Mr. John Keith, who submitted plans for a subway from the Minories to Bermondsey New road; 6, Mr. Edward Perret, who submitted plans for a high level bridge approached on the north side of the river by a level viaduct from the top of Little Tower hill, and on the south side by a level road, to be formed, each abutment of the bridge being provided with two hydraulic lifts; and 7, Mr. Edmund Walter, managing director of the Thames Steam Ferry Company, who submitted the plan of the company for a steam ferry from Irongate Stairs to Shad Thames. They also examined the designs submitted to them by the following persons which had not been referred to them by the court—namely, a design by Mr T. Chatfeild Clarke for a low level bridge 100 feet east of London Bridge, the northern approach being from Fish street hill, and the southern from Tooley street; a scheme by Mr. J. Pond Drake for a swing bridge, 50 feet wide, and a headway of 14 or 16 feet above Trinity high water mark; and a plan by Mr. C. T. Guthrie, for a railway ford, with double or single lines of railway of nearly uniform level. Only four of the parties gave any estimate of the expense of carrying their designs into execution.

PROGRESS OF THE GREAT SUSPENSION BRIDGE.

IN our SUPPLEMENT, No. 48, we gave a full description of the method to be followed in the construction of the main cables of the great suspension bridge over the East River, between New York and Brooklyn, from which cables the roadway is to be suspended.

We now give an illustration from the *Daily Graphic*, taken from the Brooklyn tower, showing the operation of stretching across the river one of the steel wire ropes, 2¼ in. in diameter, intended for the support of the foot bridge, to be used by the workmen in passing to and from their position on the "cradles" during the construction of the great cables 16 in. in diameter. As seen in the drawing, there are two men on the platform called the "buggy," one of whom is engaged in fastening the "foot bridge" rope to the "traveller" rope by means of iron hangers, which are grooved wheels from which depend a pair of "sister hooks," at intervals of thirty feet or so; the engine being started and the "traveller" performing its duty, until by a signal the engine is stopped, and another hanger added. This operation going on until the rope is stretched across a bay. As the strain is very great on the "traveller," the hoisting of the foot bridge rope is assisted by a dummy engine with a hempen rope, which is fastened at intervals to the foot bridge rope. This is done by a man who descends and lashes the two ropes together at intervals.

After the rope is stretched, a man, suspended from the working ropes in a "boatswain's chair," is carried across, cutting on his voyage the lashings which bind the cable to its "carrier," and taking off the hangers.

There are now twelve wire ropes in all stretching across the river, a telegraph wire also being across. The span between the piers of this bridge is 1,600 feet, being the widest bridge span in the world.

REPORT OF THE CHIEF ENGINEER OF THE BROOKLYN BRIDGE FOR 1876.

From the recent report of Chief Engineer Roebling to the Board of Trustees of the New York and Brooklin Bridge we extract the following:

After expressing satisfaction at the results achieved in the building of the towers and anchorages, Mr. Roebling states:

"The machinery for delivering the stones on the top of the towers was so adequate that it cost no more per yard to lay the top courses than the bottom ones." When it is borne in mind that the summit of the New York tower is 345 ft. above the foundation, this is an important fact.

The line of thrust of the pointed arches of the Brooklyn tower falls about two and one half feet outside the centres of the side shafts at the floor line, but main outer cables, when drawn in laterally, modify its position to such an extent as to throw it six inches inside of that point, thus giving a position of the utmost stability.

The immense blocks which formed the keystones, weighing eleven tons each, were fitted in without trimming as they came from the quarry, showing that the thickness of the joints between the voussoirs was regulated with the proper accuracy as the arch was built. The heavy saddle and saddleplate castings were raised and hoisted into place on top of the towers at a single lift, and with great dispatch.

"In the anchorage we have only two factors to deal with—granite and gravity. The first, a material whose very existence is a defiance to the 'gnawing tooth of time;' the second, the only immutable law in nature; hence, when I place a certain amount of dead weight, in the shape of granite on the anchor plates, I know it will remain there beyond all contingencies.

"In the anchorage plates, which are huge spider-shaped castings, two alternative designs were possible—either to make them in one solid casting or to divide each casting into a number of separate thin plates, between which the chains would be inserted, the whole being united by wrought iron bars, as proposed by Mr. Allen. Castings in large masses seldom show the same rate of strength which the same metal will give with a small sectional area; but it was found easily practicable to keep the greatest thickness of metal in these plates within three inches, and as every other advantage remained with the single casting, the latter plan was carried out with perfect success.

"*Anchor Chains.*—The anchor chains are so disposed as to form the quadrant of a circle extending from a point twenty-six feet above the anchor plate, to which they are joined by a vertical section, to within twenty-five feet of the front of the anchorage, the cable itself emerging eight feet below the top of the masonry.

"In all previous wire cable bridges, each cable was composed of seven strands. This division was impossible here, as the strands would be too bulky to handle, and could not be properly laid up, when exceeding a certain diameter. The strands will lie comfortably to the circular arrangement in the saddle on the towers, and, at the same time, permit each new strand to be made on the end of the chain, so as not to be interfered with by the strands already in place.

"The next question was the choice of material, whether to use iron or steel for these bars. During a visit at Mr. Krupp's works in Essen during the year of 1867, the managers obligingly forged for my inspection an anchor bar two by nine, but would not guarantee any greater strength than 80,000 pounds per square inch of that section of steel. A subsequent comparison of relative rates of strength and prices soon showed that iron would have the preference over steel.

"*Preservation from Rust.*—The preservation of the anchor chains from rust is effected in the manner customary on previous works, by properly painting the chemically cleaned surface of the iron and then embedding the chain in hydraulic cement. The preservative qualities of hydraulic cement have been well tried by long experience.

"The main cables consist of nineteen strands. These strands are not made on land and hauled across the river, but are laid up in place; and, as they cannot be made in the position which they are finally to occupy in the cable itself, each separate strand is laid up sixty feet above this position. The length of time required to make the main cables is largely dependent on the wind and weather, and will require no less than two and a half or three years.

"Preparations for the commencement of cable making have been going on for two years past, during which time the required machinery for running out the wire from the Brooklyn anchorage has been put up, and is only awaiting the completion of the foot bridge for an active commencement.

"The cradles are supported by heavy wire ropes, suspended at such a deflection that the main strands, while being made, hang directly opposite the regulator, thus giving him every facility for handling the wires. Access is had to the cradles by means of a light temporary foot bridge.

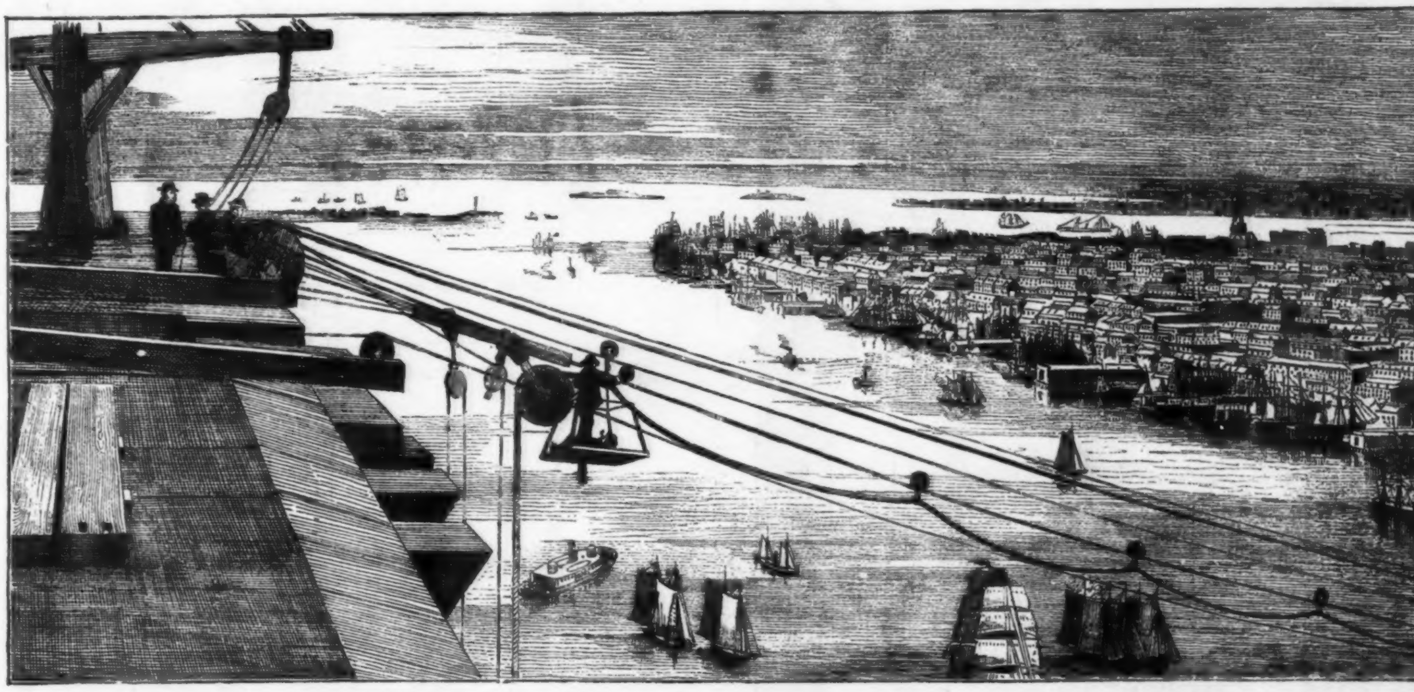
"Two designs were made for this foot bridge; one in a low position, at the level of the floor of the main bridge; the other sixty feet above, at the level of the cradles and strands. Both positions have their advantages and disadvantages."

The design for a foot bridge at the level of the cradles and strands is the one now being carried out.

"The platform or floor of the foot bridge, 3½ feet wide, is composed of wooden strips, with a small space between them, laid on top of the ropes. No suspenders are used. To protect such a frail structure against the violence of terrific gales that rage here almost weekly is no easy task, and I venture to predict that, notwithstanding every precaution, our temporary works will be disabled more than once before we have completed cable making.

"The question of the main cable wire has formed the subject of much reflection and thought, especially in preparing the specifications for the same. Tests have been going on at intervals for the past six years, and constantly during the last two years. The principle which served as a guide in these determinations was to obtain a certain rate of strength for the least amount of money. It was discovered at a very early day that a comparatively slight raise in the requirements—for instance, raising the rate from 160,000 to 170,000 or 180,000 lbs. per square inch, made a much larger proportional increase in the price; whereas a reduction of the rate below these figures did not affect the price very much.

"Throughout this whole investigation it has been felt that one grave difficulty surrounded the question of steel, and that is, lack of uniformity of quality. The plan adopted was the only one that could be practically executed—namely, to invite public competition, and to exact a large bond for the faithful performance of the contract; and, finally, to secure the qualities called for in the specifications by a complete system of tests. The assurance of the correct performance of these tests must remain a matter of confidence and trust. The building of the whole bridge is a matter of trust."



PROGRESS OF THE GREAT SUSPENSION BRIDGE BETWEEN NEW YORK AND BROOKLYN.

CONCRETE AS A BUILDING MATERIAL.

AT the recent opening meeting of the Institution of Engineers and Shipbuilders in Scotland, Mr. R. Bruce Bell, C.E., as president, delivered an introductory address, in which he said:

In sea works we have not done much of late years in Scotland of any great importance, although in this branch of engineering I have to notice the advance that has been made of late years in the use of concrete as a building material.

In works exposed to the fury of the ocean the great object has been to obtain blocks of stone of such size as to be placed beyond the possibility of being lifted by the force of the sea. The old mode of building by stones obtained from the quarry, clamped and fastened together, involved great care and cost in workmanship, and as blocks of five, ten, and even twenty tons would not of themselves, by their own weight, resist the upheaval of the waves, it was hardly possible to get stones quarried of sufficient size. This is now, however, effected by the adoption of artificial blocks of concrete. The first engineer who adopted this on a very large scale was Mr. Bindon Stoney, of Dublin, who built, and lifted, and set in place, blocks of 350 tons weight in the construction of the river wall in Dublin Bay. The machinery by which this was effected was of a most elaborate and costly character, nevertheless the work was executed at a moderate cost. The situation of this work, however, was in comparatively smooth water.

In the Tyne piers, with an exposure to the open sea of the German Ocean, Mr. Messent is laying blocks of 40 to 60 tons, and Mr. Dyce Cay has also been executing some heavy work in Aberdeen, exposed to very heavy seas; but a work at present in progress, subject to the greatest exposure, is Sir John Coode's work at Jersey Harbor, exposed to a sea and tideway unsurpassed anywhere in its destructive character. Mr. Imrie Bell, the engineer who is constructing this work, is now forming blocks of 100 tons weight, which are carried out to sea suspended under the bottom of a large welled barge and set in their places, the bottom foundation having been previously prepared with concrete in bags containing 10 to 20 tons in each, lowered through the wells of barges.

Another mode of using concrete is by setting it in a mass *in situ*, thus making the pier or wall a monolith, although it is not many years since this mode of using concrete, or of setting concrete in any form under water, was looked upon by engineers with distrust. Its first introduction for harbor works on a large scale, placed *in situ* under water, was in the foundations of the sea walls of the Albert Harbor at Greenock, which were built without cofferdams by Mr. Miller and myself in 1861, and at that time we could hardly get any engineer to support our view as to its being a reliable mode of building. Of late years, however, concrete has become a universal system of building sea works where cost and time are matters of importance.

CONCRETE BRIDGE.

AT Seaton, Eng., a three-arch bridge is being built of concrete, on a new principle invented by Mr. Brannon, of London. The idea of the inventor is that concrete would, for such work, prove far more endurable than stone. The toll house at the end of the bridge is being built on arches. Mr. Brannon suggests that by constructing cottages on arches, instead of on the solid ground, all fear of fever caused by exhalations from the soil would be avoided; and he understood that Sir Walter Trevelyan, on whose estate the bridge was being built, was about to have a number of workmen's cottages built on that principle at Seaton.

WOODEN PILLARS.

IT is stated as a curious fact that in the salt mines of Poland and Hungary the galleries are supported by wooden pillars, which are found to last unimpaired for ages, in consequence of being impregnated with the salt, while pillars of brick and stone, used for the same purpose, crumble away in a short time by decay of their mortar. It is also found that wooden piles driven into the mud of salt flats and marshes last for an unlimited time, and are used for the foundation of brick and stone edifices; and the practice of docking timber by immersing it for some time in sea water, after it has been seasoned, is generally admitted to be promotive of its durability.

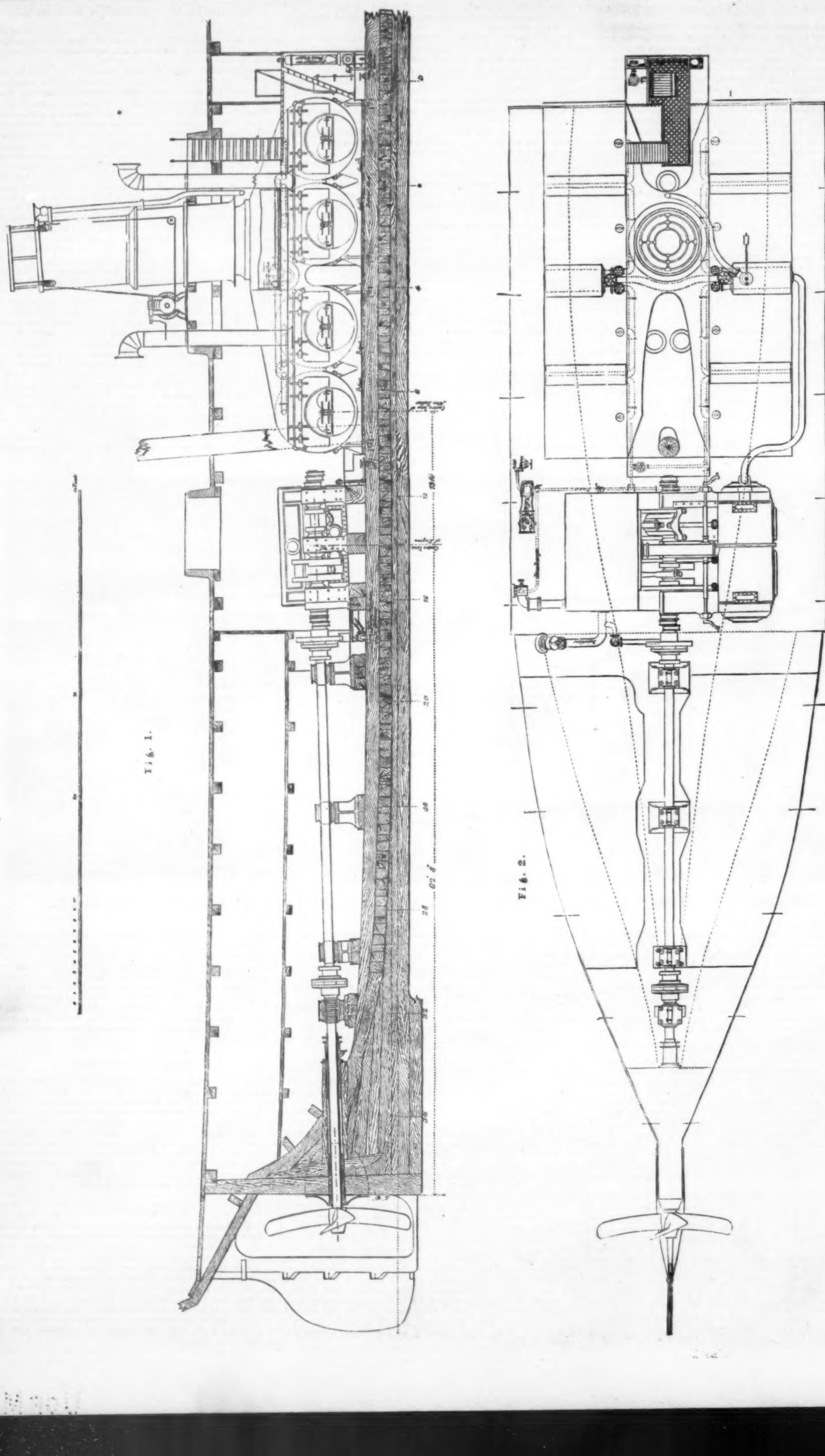


Fig. 1.

Fig. 2.

GENERAL ARRANGEMENT OF MACHINERY, U. S. STEAM SLOOPS CONSTRUCTED BY THE NAVY DEPARTMENT.

MACHINERY OF THE AMERICAN STEAM SLOOPS.

OUR engravings show the general arrangements of the engines and boilers of one of the American wooden-built sloops of war of 620 tons measurement. A pair of engines for this class of vessels was exhibited at the Philadelphia Exhibition by the Bureau of Steam Engineering of the United States Navy Department, by which Bureau the engines were designed and constructed. The engines are of the compound intermediate receiver type, with return connecting rods fitted with surface condensers. The cylinders, which are both steam-jacketed, are respectively 34 in. and 51 in. in diameter, with 3 ft. 6 in. stroke. There is one air pump and one circulating pump, each being double-acting, 13 in. in diameter, and with the same stroke as the steam pistons. The surface condenser contains 1,788 tubes, ⅝ in. diameter and 9 ft. 3 in. long, between tube plates, the surface they expose being thus 32,472 square feet.

The engines are intended to indicate 800 horse power, and are supplied with steam at 80 lb. pressure by eight boilers, each 8 ft. long over all by 8 ft. in diameter. Each boiler contains but a single furnace, but this is 4 ft. 6 in. in diameter. The total heating surface exposed by each boiler is 598·21 square feet, of which 458·7 square feet is tube surface. The grate surface is 24 square feet, and the flue area through the tubes is 3·186 square feet. The ratio between flue area and grate surface is thus, 1 : 7·53, and that between grate surface and heating surface, 1 : 24·93.

The engines are placed immediately aft the boilers. The shaft has an inclination at about 1 in 31. The machinery occupies a space of about 16 ft. in length. The eight multitubular boilers, four placed on each side of the vessel, the stokehole (8 ft. wide) running fore and aft between them. They occupy altogether a length of 40 ft., so that the total distance between bulkheads is about 56 ft. The vessel in which they are to be placed is, as stated, a wooden sloop of 620 tons measurement, and the distance from the center of the engines to the stern post is 63 ft. 8 in. Between the crank shaft and the propeller shaft there is only one intermediate shaft, which has three bearings. The thrust bearing is placed on the propeller shaft, just forward of the stern tube. Each set of four boilers has a common uptake, the two uptakes uniting and forming the base of a single telescopic chimney.

The general arrangement of the machinery is a somewhat peculiar one. The low pressure cylinder has two piston rods crossing the shaft and a return connecting rod in the usual way. In the high pressure cylinder, however, there was not room for the two rods, and the piston carries a central rod only. This rod is fitted with a crosshead, made so as just to clear the crank when at the front of its stroke. This crosshead is placed obliquely, and is guided in the framing at both ends. It is connected with a crosshead of the usual construction by a pair of rods, and from this second crosshead the shaft is driven. The arrangement permits a longer stroke to be used with a given capacity of cylinder than would otherwise be possible; it seems open to serious question, however, whether it would not have been wiser to use cylinders of larger diameter and less stroke, so that both might have been driven in the usual manner, and the intermediate crosshead, with its guides, &c., rendered unnecessary.

Both high and low pressure cylinders are steam jacketed and fitted with expansion valves. They are enclosed in a casing which serves as an intermediate receiver. The valve chests are large castings bolted to the sides of the cylinders and extended downwards so as to rest on the timbers. These castings are also bolted directly, along with the cylinders, to the framing. The frames are open, they have single webs and broad cross feathers, and are adorned with a certain amount of moulding of a kind which finds more favor among American engineers than here. The two forward bearings are of the same length; the after bearing, however, is somewhat longer and the after frame a good deal stiffer than the others.

The surface condenser and pumps are placed on the port side of the vessel. The tubes are horizontal, and placed fore and aft, the condenser itself being a rectangular chamber carried right over the main crossheads, and clear of them, supported only at the two ends. The casting which forms the guide for the high pressure crosshead contains also the air pump with its valve chambers and the hot well, and carries the forward end of the condenser. Similarly, the casting which forms the guide for the low pressure crosshead contains the circulating pump, and supports the after end of the condenser.—*Engineering.*

Fig. 3.

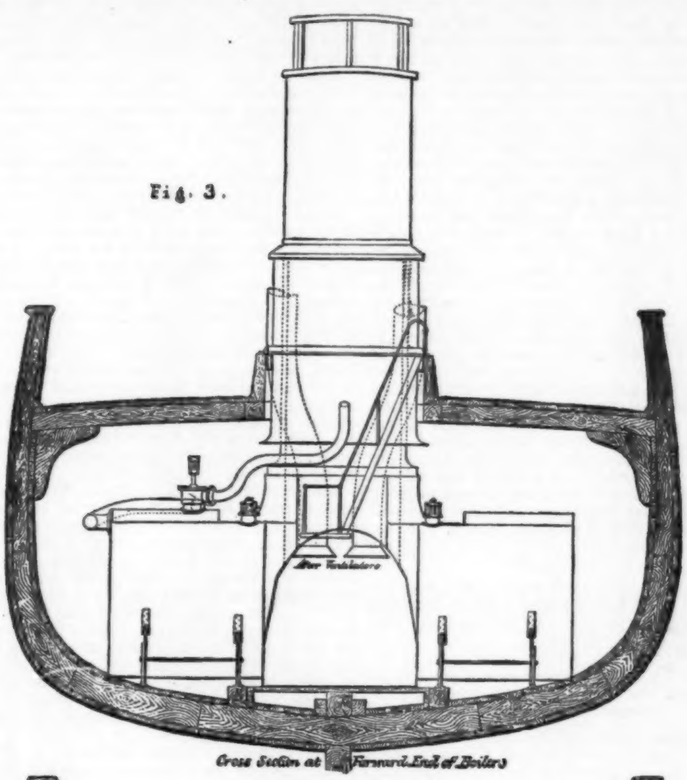
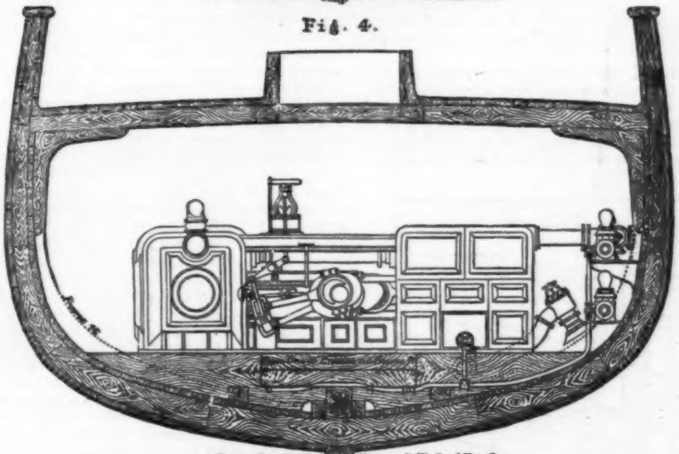


Fig. 4.



GENERAL ARRANGEMENT OF MACHINERY, U. S. STEAM SLOOPS.

HISTORY OF THE ART OF COACH BUILDING.*

By G. A. THRUPP, Esq.

THE progress of the art of coach building, like the progress of most inventions and discoveries, has been slow. In certain ages it has seemed to make a sudden start, then again to remain almost stationary for a long time.

It is only during the last two centuries that coach making has been in a satisfactory condition as an art, and it has arrived at comparative perfection only during the present century. The same, however, may be said of other inventions:—Pendulum clocks were invented about 1260; paper was made from old rags about 1250; gunpowder dates from the year 1330; printing, that valuable aid to the arts, 1430; watches are said to have been first made in England about the year 1500; and the first coach was seen in England in the year 1555, three hundred and twenty years ago.

The history of coaches and carriages is not as extensive as the human race, nor can it be traced among all those nations that have arrived at an advanced stage of civilization. Ancient America, especially the civilized Mexico, tells us nothing, from China and Japan we gain next to nothing; and only a strip of North Africa contributes to the history of wheels. But Europe, Asia Minor, Hindostan, and Tartary furnish nearly all the information we can glean.

The history of the art of coach making must be divided into several marked epochs. The first terminates with the change of government at Rome from the rule by Consuls to the rule by Emperors, about 2,000 years ago; during this period there was little variation in the vehicles chiefly used. The second epoch terminates with the overturning of the Roman empire, about 1,500 years ago; during that epoch, which was one marked by the display of great wealth, and the indulgence of most luxurious living, several new and larger vehicles were introduced, and many were decorated in a costly manner. The third epoch commences with the introduction of vehicles slung upon leather straps, and may be considered to end about the year 1700, when the use of steel springs began to be understood. The fourth epoch will end in 1790, when coaches began to assume their present form, size, and style. And the last epoch must commence with the introduction of carriages hung wholly on elliptic springs, about 1805, by Mr. Obadiah Elliott. This last and surprising change has been productive of very important results to all interested in the use of carriages or in coach building. By the introduction of elliptic springs the construction of wheeled vehicles has been rendered less costly, their weight has been materially reduced, and many complicated parts have been abandoned. Simultaneously, the number of vehicles has been multiplied, and their comfort and accommodation has been increased.

We may fairly suppose the first means of locomotion entitled to the name of a carriage to have been a sledge. It would be so natural to place a burden, too heavy for the shoulders, on some slight framework and drag it over the ground. A very little experience would enable a man to judge of the best form for a sledge; and, in point of fact, the first sledge of which we find any record, on a sculpture of the Temple of Luxor, at Thebes, in Egypt, is precisely similar to that used by brewers' draymen in London. It has two long runners slightly turned upwards in front, and half a dozen cross pieces to unite the runners and bear the burden. Sledges of many shapes and fashions are in use during the winter in most countries where snow lies for any length of time upon the ground, as sledges glide more easily over its surface than do wheels. The Esquimaux and the Laplanders habitually use sledges, all more raised from the ground than the sledge that carries the casks of the brewers. The Swiss and other inhabitants of mountain districts use sledges to bring down hewn timber and fagots to the valleys; and a hundred years ago, when carts were not so numerous, it was common in England to load the newmade hay or sheaves of wheat on light high sledges for transport to the farmyard. In North America and Northern Europe, sledges of elegant shape are every year in use; and in Holland and Belgium, during some winters, not only do the gentry ride in sledges two or three months, but the meat, bread, and vegetables are run through the streets daily on hand sledges.

Egypt is the chief of the countries of which we have any record of the arts and manufactures introduced by the progress of civilization. Egypt had, at an early period, buildings composed of very large stones; in moving these the sledge and the roller were used; and it is natural that these should be combined to form a low truck, or platform moving on rollers. Later on, wheels and axles were substituted for rollers; at first wheels were slices of the trunk of a tree, all solid pieces of wood, and firmly wedged to the axles. Thus the wheels and axle revolved together below the cart or truck, and were retained in their position by strong wooden pins like the thole-pins or rowlocks of a boat. The wheels and axle revolve together in tramway cars and in railway carriages. Carts are made in this way now in Portugal, Spain, and in South America. All the earlier carts seem to have been fitted only with a pole, and at least two animals seem always to have been yoked together to the vehicle. The objection to the wheels and axle in one piece is, that it is difficult to turn a vehicle thus fitted in a small space. Any one using a garden roller round a corner may easily convince himself of this, for whilst the outer edge of the roller is going over the necessary sweep, the inner edge is sliding on, and crushing the gravel walk; it should be moving independently. It was soon discovered in Egypt that it was better to have a fixed axle tree, and allow the wheels to revolve independently of one another.

A wheeled carriage appears to have been in very general use in Egypt at an early period, called a car or chariot; in the Bible it is usually translated "chariot." There are paintings and sculptures upon the walls of the temples and tombs of Egypt which have lasted 4,000 years, and from those we learn precisely the appearance of these chariots. They are of great interest to us, as they formed the chief means of conveying man for 2,000 years before Christ, and were more or less the type of all other vehicles of the ancient world. We find certain words used in describing them, both by Homer, who lived 1,000 years before Christ, and by Moses, who lived at least 500 years earlier, and that the words are technical terms, such as axles, wheels, naves, felloes, tyres, spokes, etc. Now technical terms imply that the art that had such terms must have existed prior to the writer who speaks of the art, so that, if we hesitated as to the date of the chariots sculptured and painted on the walls of the Egyptian temples, we are reassured by the terms used by the authors we name. Moses, in the description of the wheels upon which moved the great cauldron used by the priest, and Homer, in describing the car of the goddess Juno, used the same terms. We read in the fifth book of the Iliad, "The awful Juno led out the golden bitted horses, whilst Hebe fitted the whirling wheels on the iron axles of the swift chariot. The wheels had each eight brazen spokes, the felloes were of gold secured with brazen tyres all round, admirable to the sight. The seat was of gold, hung by silver cords; the beam or pole was of silver, at the end of which was hung the golden yoke and the golden reins." These cars were occasionally square, but more generally semicircular or horseshoe shaped; the rounded front towards the horses was high, the sides lower, the back was open, and the bottom was near the ground, so that it was easy to step in and out. The wheels, especially in Egypt, are very low, from 2 ft. 6 in. to 3 ft. 3 in. in height. The framework of the body was often open, but sometimes closed up with leather skins or basket work, and occasionally with carved wood or embossed metal. The pole by which it was supported curved up from the bottom of the bar to the backs of the necks of the horses or

* A Lecture recently delivered before the Society of Arts, London.

oxen, where it was joined to a wooden yoke; this was again strapped round the bodies and necks of the horses, or tied to the horns of the oxen. The addition of bridles and reins would complete the simple harness. Some horses were attached to the pole by an iron bar with knobs at each end, which passed through a ring at the end of the pole, and through a similar ring upon each of the pads or saddles of the horses. This would be very similar to the curricle bars used in modern time, and would allow of more freedom in motion than a fixed yoke would give. The bodies of these chariots, in Egypt at least, were small, usually containing but two persons standing upright. It may be remarked that, as they were so small, they could not have been of much use, and from the small size of the wheels, too, they would be jolted by every little obstacle on the road; and, as they were so near the ground, those using them would be exposed to mud and dirt; yet, in spite of these objections, they were used in vast numbers. They were very light, and could be driven at a great speed—nearly as fast as the horses could gallop. They were narrow, and, therefore, suitable to cities in which the streets are still very narrow, and to mountain roads which were often only 4 feet wide. They suited the period and the people, or their usefulness would not have lasted 2,000 years. According to Homer, a strong man could lift a chariot on his shoulders and carry it away. Possibly this would be without the wheels, but even then it could not have been heavier than one of our wheelbarrows. From Egypt the use of chariots spread into other countries, and they were used in war in large numbers upon the extensive plains of Asia. We read of the 900 chariots of Jabin, king of Canaan; that David took 700 chariots from the kings of Syria, and 1,000 from the king of Zobah. Solomon had 1,400 chariots, and his merchants supplied northern Syria and the surrounding countries with chariots fetched up out of Egypt at 600 shekels (about £50) apiece. They were not the first nor the last merchants who have preferred their pockets to their patriotism, and supplied nations who might become their country's enemies with the weapons of warfare. Solomon, we find in the Song of Solomon, built a state or wedding chariot of cedar with pillars of gold, probably supporting a canopy. We may also notice the poetic description by the prophet Nahum of the future state of Nineveh, no longer to echo "to the noise of the chariots raging up and down the paved streets, jostling against one another in the broad ways, with the crack of the whip, the rattle of the wheels, the prancing horses and the jumping chariots;" and the remark in another place of "the stamping of strong horses, the rushing of the chariots, and the rumbling of the wheels," all pointing to the great impression which was made upon the prophet of the wilderness by the carriages and noise of the crowded city. In a museum of New York is a wheel of an Egyptian chariot, found in a mummy pit at Dashour, by Dr. Henry Abbott. It is 3 ft. 3 in. high, the nave is 14¼ in. long, and 5 in. in diameter, and worked upon an axle of wood which tapered, and was from 3 in. to 2½ in. in diameter. The unusual size and length of this axle arm would be very apparent in so small a vehicle as the Egyptian chariot; the spokes, six in number, are 2 in. by 1⅝ in. at the nave, and taper towards the felloe to 1⅜ in. round; it has a double rim all round. The six inner felloes do not meet as in modern wheels, but are spliced one over the other, with an overlap of 3 in.; the felloes are 1½ in. square. The outer rim is formed also of six felloes, but they are tenoned together, and are pierced all round the lower edge with small holes, through which, we may well conjecture, leather thongs passed, binding the outer to the inner rim. The total depth of the double rim is 3¼ in. by 1¼ in. to 1½ in. in width. From the ancient sculptures preserved from Nineveh and Babylon, some of which are in the British Museum, we observe the use of chariots was continued in the great plains, for the purposes of hunting as well as for war. The chariots of Assyria were larger than those of Egypt, and would carry three or more persons; they seem, too, much heavier in the build. The Greeks used chariots, and at the siege of Troy, which Homer has immortalized in his poem, all the chief warriors on both sides are described as going into battle and fighting from their chariots. As years passed on, however, the Greeks no longer used chariots for war, but only for processions in public on state occasions, or in their great races, or for the amusement of their leisure hours. Erectheus, king of Athens, is reported to have been the first to drive four horses in a car; afterwards it became common to use, in the races, four horses attached to each car. The Grecian chariots were all curved in front, and were rather larger and on higher wheels than those used in Egypt.

The Roman nation, as it increased in power, adopted the car, which had also been for many years in use by the Etrurians, a neighboring country to their own in the Italian peninsula. The Etrurians were traditionally the first to place a hood or awning over the open two wheeled car; they decorated both the car and the awning with that beautiful tracery and ornamental bordering which is familiar to us from the copies of their pottery. The Roman car was chiefly used in the cities, and for purposes of show and state rather than for daily use. A beautiful marble model of one of these still exists at the Vatican of Rome; a copy of it and the horses drawing it is in the Museum of South Kensington.

Besides the chariots, the Romans had other two-wheeled cars, and four-wheeled wagons of different shapes, and giving different accommodation; but first they were kept for conveying agricultural produce, and for moving goods and baggage, and the better sorts were reserved for the conveyance of the images of their gods and vestal virgins in religious processions. Then came the triumphal processions of successful military commanders, and a variety of vehicles conveyed the conqueror, the captives, and the arms and valuables taken from the enemy. Plutarch tells us that Emilius, the Roman Consul, had 750 wagons in his triumph in the year 170 B.C., bearing the spoils of Perseus, last king of Macedonia. On the column of Trajan at Rome is modelled one of these wagons. It is a large square basket on four wheels, the back a little higher, and the hind wheels also are a very little higher than the front.

Roman history, of the time of Camillus, 350 B.C., mentions a carriage termed a pilentum, as a splendid four-wheeled carriage with a covering to it, and with seats suspended by straps. The use of these pilenta was allowed as a special favor to a few great Roman ladies. The Empress Agrippina also had a carpentum, an elegantly carved carriage on two wheels, the arched covering of which was supported by four female statues; it was drawn by two mules. The Romans also used basternæ, which were litters or couches with low coverings, carried on poles by horses or mules; and lecticæ, or litters carried by men only. The Roman chariot was called a currus.

Herodotus (450 B.C.), and other writers tell us of the vehicles of the ancient Scythians. These were a race of people who inhabited the country near the Caspian Sea, and wandered about with large herds of cattle and horses. They used a rough two-wheeled cart which consisted of a platform, on which they placed a covering shaped like a beehive, and composed of basket work of hazelwood covered with skins of beasts or thatched with reeds. When they were stationary in any part, these beehive huts were taken off the carts and placed upon the ground to serve as their dwellings, like gipsy tents.

The war chariots used by the Persians were larger and more unwieldy than those previously built. The idea seems to have been to form a sort of turret upon the car, from which several warriors might shoot, or throw their spears. These chariots were provided with curved blades or scythes projecting from the axletrees. The Persians had also cars that were used for state processions, in which the king or noble was raised above the crowd among which he passed on a sort of throne of many steps.

The Dacians, who inhabited Wallachia on the Danube and part of Hungary, were conquered by the Romans about the year 300. Their cars are sculptured upon Roman monuments, and resemble the Persian cars. They are on two wheels and drawn by two horses; the shape is that of a large square box or chest, with a smaller box upon it, which formed a seat for the passengers. The spokes of the wheels are six in number, and are widest at the ends supporting the rims of the wheels. A Dacian car of this sort is represented upon a fragment of terra cotta in the British Museum.

Alexander the Great, King of Macedon, invaded Asia and advanced to India; he was met upon the banks of the river Indus by King Porus, in whose army were a number of elephants of large size, and also several thousand chariots; each chariot carried six persons; but the historian notes that in a soft soil or in rainy weather it was difficulty for these vehicles to move quickly. On Alexander's return from India towards Persia, he travelled in a chariot drawn by eight horses, on which a square stage or platform was erected and covered in by a tent. His car was followed by an innumerable number of others, covered with rich carpets and purple coverlets; some shaped like shells or cradles were shaded with the branches of trees. I have seen a drawing of a Persian car in which the body is raised above the wheels and seems to swing from pivots like a large cradle, or such a cot as is used on board ship. After Alexander's death a funeral car was prepared to convey his body from Babylon to Alexandria, in Egypt, a distance of several hundred miles, which car perhaps has never been excelled in the annals of coach building. It was prepared during two years, and was designed by the celebrated architect and engineer, Hieronymus. It was 8 ft. long and 12 ft. wide, on four massive wheels, and drawn by 64 mules, eight abreast. The car was composed of a platform with a lofty roof supported by 18 columns, and was profusely adorned with drapery and gold and jewels; round the edge of the roof was a row of golden bells; in the center was a throne, and before it the coffin; around were placed the weapons of war and the armor that Alexander had used. This car was thought so much of that several historians have described it, and there are various plans of its appearance, one of which may be seen in Ginzrot's work on ancient carriages in the British Museum library.

(*To be continued.*)

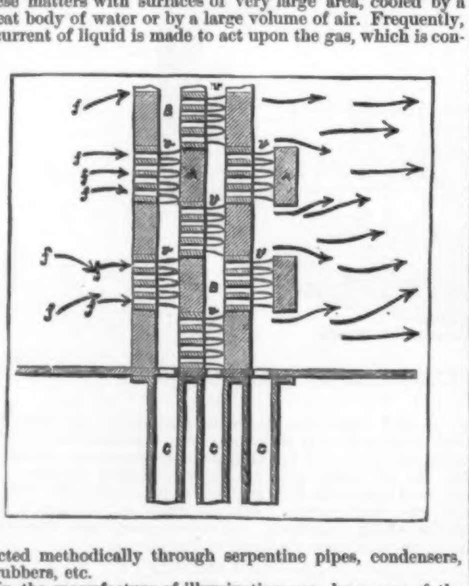
MM. PELOUZE AND AUDOUIN'S NEW APPARATUS FOR THE MECHANICAL CONDENSATION OF THE LIQUEFIABLE MATTERS IN GASES OR VAPORS.

By M. FELIX LE BLANC.

(Report presented to the "Société d'Encouragement pour l'Industrie Nationale," on behalf of the Chemical Arts Committee.)

THIS is a new apparatus, designed by MM. Pelouze and Audouin, of Paris, with a view of obtaining a more perfect condensation of the tar produced in the manufacture of illuminating gas, but equally applicable for the condensation of the various liquefiable matters contained in other gases or vapors.

The apparatus employed up to the present time for the condensation of these matters has been generally based upon the lowering of temperature resulting from the contact of these matters with surfaces of very large area, cooled by a great body of water or by a large volume of air. Frequently, a current of liquid is made to act upon the gas, which is conducted methodically through serpentine pipes, condensers, scrubbers, etc.



In the manufacture of illuminating gas, by means of the distillation of coal, the condensation is almost exclusively obtained with the aid of apparatus arranged on these principles. This condensation is efficacious merely by reason of the cooling imparted to the vapors existing in suspension in the gas at a more or less elevated temperature, after the manner of steam in atmospheric air. Recourse is occasionally had to another method, based upon the compression of the gas; this method is, however, but rarely employed, except in the manufacture of what is called *portable* gas, obtained almost exclusively by the distillation of bituminous schists called Boghead.

The process proposed by MM. Pelouze and Audouin is based upon an essentially different principle. Impressed, like most chemists, with the difficulty of avoiding the transport to a distance, and in a liquid state, of globules or vesicular vapors, and of arresting them while on their passage, before the arrival of the gas at the purifier, they have proposed to effect this by bringing these vesicles into contact with solid surfaces, after having caused them to traverse, under a pressure of at least from 50 to 60 millimètres (2 to 2¼ inches) of water, a series of narrow orifices made in metallic plates.

The apparatus may be constructed of a rectangular or a cylindrical form, of sheet iron, and having thin sides. These are pierced with several sets of small holes. The streams of gas having traversed these orifices, are projected against a fixed solid surface placed close to the perforated plates.* The liquid globules carried forward are wire-drawn in the course of their passage through the holes, and afterwards consolidating on coming in contact with the flat surface, soon acquire sufficient weight to cease to remain in suspension; they therefore flow down in the form of a liquid easy of collection in proportion to the rate at which it is produced.

The above engraving shows the arrangement of the apparatus. The arrows *f f f* indicate the direction of the gases or vapors. The lines *v v*, shown between the plates, A and B, represent the form presumed to be taken by the jets of gas which have come in contact with the screen after their passage through the orifices. A A are plain surfaces, forming screens, on to which the gas is projected. B B are small circular orifices to allow of the escape of the gases or vapors. C C are the outlets for the products of condensation. This mechanism renders the condensating action instantaneous, and the tarry matters, which had not before undergone decomposition by cooling during their long passage in contact with large refrigerating surfaces, now become liquefied, and flow away in the space of a few millimètres.

Experience has taught us that in gas works it is impossible for the gas to reach the purifiers divested of the tar it holds in suspension, notwithstanding its somewhat long journey from the hydraulic main through the condensers, scrubbers, etc. It is true that the tarry matters carried forward condense on coming in contact with the purifying material, but little by little they clog up the oxide of iron, and thus render the purifying process less perfect and more costly.

It can be easily shown that illuminating gas, on its arrival at the purifiers, still holds in suspension tarry matters which could not be precipitated by the simple process of cooling. To do so it is sufficient to pass a stream of gas, under a pressure of at least two or three inches of water, through a narrow orifice in a funnel-shaped vessel. A piece of white paper, placed over the wide orifice of the funnel, and made to receive the full force of the current of gas, is instantaneously blackened by a deposit of tarry matter. This deposit ceases to be produced, and the paper remains white, when the gas submitted to this test has been previously passed through MM. Pelouze and Audouin's condenser. We submit to the Society's notice a number of test-papers, which have been acted upon by the gas, both before and after its passage through the condenser. In the former case, the disc of paper is invariably blackened; in the latter case it remains white.

The experiments made in the works of the Paris Gas Company during the coldest weather of last winter were most conclusive. At the Ternes station, especially, the condensers, which are of considerable extent, and the coke scrubbers, proved inadequate to deprive the gas of the whole of the tar it held in suspension. This could only have been done by the employment of very small wetted pebbles, which would leave narrow spaces between them; but with this arrangement the scrubbers would be rapidly obstructed. Now, under the previously cited conditions of temperature, the mechanical condenser, placed after the refrigerators, acted most efficaciously in completing the condensation of the tar.† Thus the apparatus which is the subject of this report solves, with very great simplicity, the problem of the condensation of the tar by impingement.

Figs. 1 to 5 are representations of MM. Pelouze and Audouin's new condenser, which has already been erected in a great number of works.

Fig. 1 represents in elevation the condenser connected with the gas-main on the works. A is a differential pressure-gauge indicating the pressure aborbed by the gas through the perforated sides of the condensation cylinder.

Fig 2 is a plan of the condenser corresponding with Fig. 1. B is the gas inlet-valve; C, the outlet-valve; D, a clack-valve for allowing the gas to pass direct into the main in the event of the stoppage of the condenser for cleaning, repairs, etc.

Fig. 3 is a vertical section of the condenser: *a* is a cylinder of perforated sheet iron, constituting the condenser; *b*, channel or annular space in which the cylinder moves and the tar produced by condensation accumulates; *c*, receptacle for the tar overflowing from *b*; *d*, inlet for the gas charged with tar; *e*, outlet for gas after purification; *f*, pipe, terminating in a syphon, for carrying away the products of condensation falling into the receptacle *c*; *g*, guide with hydraulic seal and counterbalance weight, allowing of the variation in the movements of the cylinder(which is also a self-acting regulator) proportionately to the quantity of gas produced at any time during the day; *h*, pipe by which the channel *b* is filled when the apparatus is put into action; *i*, pipe for emptying the channel *b* for cleaning or repair; *j*, graduated scale for indicating the height of the cylinder out of the hydraulic seal.

Fig. 4 shows portions of the plate of perforated sheet iron forming the sides of the cylinder, and Fig. 5 is a transverse section of the plates; *k* represents the perforated plate which divides the gas into jets; *k'* is the second plate, presenting a series of plain surfaces corresponding to the openings in the plate *k*, and against which the gas is projected.

Before arriving at the purifiers, the gas passes through the vertical sides of the sheet iron condensation cylinder, which is of relatively small size; a single one of about 35 cubic feet capacity suffices for gas works producing 3¼ million cubic feet of gas per 24 hours; and the apparatus acts equally well whether the works are provided with exhausters or not. The openings in the cylinder should be proportionate in number to the volume of gas required to pass through the apparatus in a given time.

In order to obtain as complete a condensation as possible, the inventors have added to the first set of plates, with which

* In gas works MM. Pelouze and Audouin place their condenser after the refrigerators, in the position usually occupied by the coke scrubbers, although they state that if the apparatus be fixed at the outlet of the hydraulic main—that is to say, made to act upon a very hot gas (having a temperature of about 60° C.), it is capable of arresting the whole of the tar. To work under the best conditions, the condenser ought to receive the gas coming from the refrigerators at a temperature of 15° C., which is about the average temperature of the subsoil.

† Chemists well know the difficulties which present themselves when the absolute desiccation of a gas in motion is required, as well as the absorption by a liquid reagent of an absorbable gas disseminated in small quantities in a relatively large volume of nonabsorbable gas; as, for example, carbonic acid in atmospheric air. It would be impossible to succeed by causing the gas to bubble through the absorbent liquid. More than 35 years ago, M. Boussingault overcame this difficulty by making the gas pass through long columns of finely granulated matter (pumice-stone), which was wetted with the absorbent liquid. These means are still employed in all chemical laboratories. They would succeed for the condensation of the tar, but in commercial practice the inconveniences above mentioned would quickly manifest themselves.

the gas first comes in contact, a second set, which are placed close to the others, so that the stream of gas may sustain two successive collisions against the screens, the effect of which is to produce absolute condensation. As the plain portions only of this second set of plates are brought into action, the inventors have considerably enlarged the diameters of the openings, in order to facilitate the flow of the condensed tarry matters. This arrangement, which has been recently adopted, is found to be very successful.

It was of importance to render the apparatus self-acting; that is to say, to so arrange it as to ensure the passage of a greater quantity of gas whenever the production of the works increased. The cylinder, properly balanced, is capable of acting as its own regulator. For this purpose it moves in a hydraulic seal, which allows of the closing of those gas passages which are not required to be in action. When the pressure increases—and this will correspond to an increase in the production of gas—the cylinder rises, and a larger number of openings are uncovered to allow the gas to pass through.

At the expiration of a certain time, variable according to the nature of the tar produced (once or twice a year at least, or at most once a month), the apparatus should be cleaned. This may be effected in a few minutes by immersing the cylinder in a bath of boiling water, which liquefies any tar that may be obstructing the orifices. (If required, a thin stream of vapor may be supplied from a small serpentine pipe, placed in the channel, to prevent the tar from falling to too low a temperature.) An inspection of the pressure-gauge will indicate when this operation has become necessary, the fouling of the apparatus causing an increase of the normal pressure over that which is required for its proper working.

In an experiment made at the Ternes station of the Paris Gas Company, which, as we have said, is provided with powerful refrigerators, and produces 100,000 cubic mètres (about 3½ million cubic feet) per 24 hours, 253 kilogrammes (556 lbs.) of tar, and 30 litres (6½ gallons) of very rich ammoniacal liquor were obtained at a relatively low temperature. These quantities represent a period of production of 28,200 cubic mètres (about one million cubic feet) of gas. The quantity of tar contained per 1,000 cubic mètres (35,300 cubic feet) was, therefore, 8·9 kilogrammes (about 19½ lbs.). From 9 to 10 kilogrammes (20 lbs. to 22 lbs.) of tar condensed by the effects of collision may be allowed per 1,000 cubic mètres of gas, when the temperature is relatively low, and when the works are already provided with tolerably powerful cooling apparatus.

It is clear that the new condenser may be employed otherwise than in gas works, either for obtaining *dry* steam, or for arresting the liquid globules and particles of solid bodies carried away simultaneously during the evaporation of liquids. These applications of the apparatus have been foreseen by the inventors.

Quite recently, MM. Chevé and Girard, manufacturers of acetic acid and wood spirit, have adopted MM. Pelouze and Audouin's condenser at their works at Courville (Eure-et Loire), and are quite satisfied with its employment in the treatment of the products of the distillation of wood. It may also serve, as indicated by the inventors, to arrest the metallic or other dust arising from certain manufactures; this is done by damping the walls of the apparatus, or by sending into the gaseous current a jet of spray.—*Journal of Gas Lighting.*

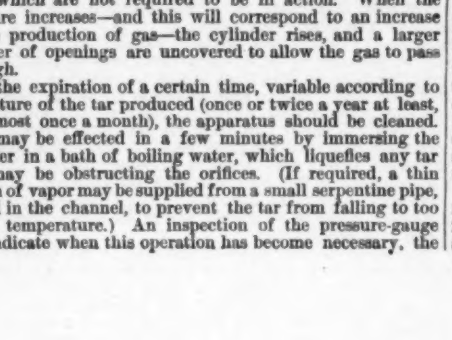


FIG. 1.

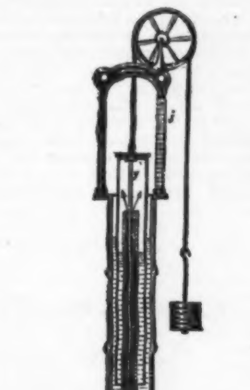


FIG. 3.

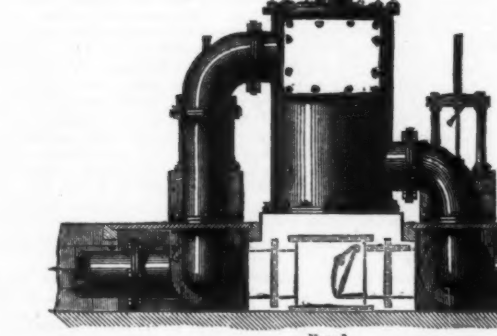


FIG. 2.

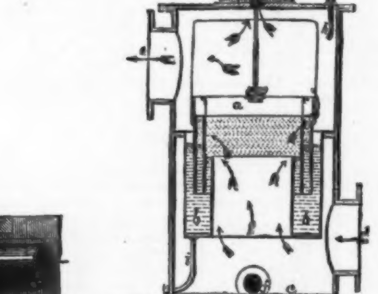


FIG. 5. FIG. 4.

CONDENSING APPARATUS FOR LIQUEFIABLE MATTERS IN GASES.

A NEW AND REMARKABLE GAS BURNER.

AT a recent meeting of the Manchester Chemists and Druggists' Association, Mr. John Wallace exhibited a series of gas burners o' the Bunsen or atmospheric type, by which he demonstrated that very high temperatures could be obtained from coal gas without the aid of either blowpipe or chimney draught. The chief feature of the Wallace burner is a cylindrical cap of finely perforated metal fitting over the top of the tube, and made adjustable to various heights, so as to regulate by back pressure the quantity of air drawn in by the jet of gas to be mixed with it previous to combustion. As the perforations in the cap are too small to allow the passage of a flame downwards, a much more inflammable mixture of air and gas may be burned than would be possible with another form of burner. The result of this arrangement is that a flame may be obtained which is perfectly solid, containing no hollow conical space within, as is usual with all other round flames; it burns with a temperature of over 3,000° F., and its peculiarities involve a new theory in the structure of flames. Instead of a dull blue color within, it presents to the eye a spectrum of the most intensely brilliant green at that part of the flame where combustion commences. Above this the flame is of an amber color, and combustion is so complete that it makes no stain if played upon a white porcelain plate.

The tubes of the burners exhibited varied in diameter from ¼ in. to 2 in., the largest burning 30 to 35 cubic feet of gas per hour in a manner as completely as did the smallest.

One of the ¼ in. burners was perforated with half inch air holes for its whole length, and yet burned gas above the cap with a heat which rendered a twisted mass of platina wire immediately incandescent. A link of ⅛ in. wire was added to a chain of copper and the joint of the link fused together by simply suspending it over the flame. The gas in all experiments was taken direct from the chandelier of the room. By careful experiments made with the test apparatus of the Newcastle-on-Tyne Gas Company, Mr. Wallace found he could mix previous to combustion $4\frac{6}{10}$ volumes of air in his burner with gas whose total combining quantity was 6½ volumes. The experiments concluded by the exhibition of a singeing flame.

A one inch burner was made to burn within the end of a piece of 3 in. stove pipe 4 feet long. The loud monotonous roar which followed, although it crowned the experiment with success, showed that the title was a complete misnomer.

MINING AND METALLURGY IN THE UNITED STATES.

IN order that a clear idea may be formed as to the relative position now held by the United States in the world of mining and metallurgy, I have selected the production of coal, which is the main reliance for power of all organized industry, and of iron, which is the chief agent of civilization, as the basis of comparison with other nations, using, so far as coal is concerned, the figures given in the Forty-third Annual Report of the Philadelphia Board of Trade, for the year 1873:

	Tons.	Per Cent.
Great Britain	127,016,747	46·4
United States	50,512,000	18·4
Germany	45,335,741	16·5
France	17,400,000	6·4
Belgium	17,000,000	6·2
Austria and Hungary	11,000,000	4·0
Russia	1,200,000	0·5
Spain	570,000	0·2
Portugal	18,000	—
Nova Scotia	1,051,567	0·4
Australia	1,000,000	0·4
India	500,000	0·2
Other countries	1,000,000	0·4
	273,704,055	100·0

The following estimate, in round numbers, of the world's present production of iron is taken from various sources, and may be considered approximately correct. The figures for Great Britain and France are those of 1874, and the product of the United States for the same year has been taken. For other countries the estimates are principally for 1871 or 1872, except Austria and Hungary, for which the official returns for 1873 have been taken:

	Tons.	Per Cent.
Great Britain	5,991,000	45·2
United States	2,401,000	18·1
Germany	1,600,000	12·1
France	1,360,000	10·3
Belgium	.570,000	4·3
Austria and Hungary	365,000	2·7
Russia	360,000	2·7
Sweden and Norway	306,000	2·3
Italy	73,000	0.5
Spain	73,000	0·5
Switzerland	7,000	—
Canada	20,000	0·2
South America	50,000	0·4
Japan	9,000	0·1
Asia	40,000	0·3
Africa	25,000	0·2
Australia	10,000	0·1
	13,260,000	100·0

An examination of these tables will serve to show that, in the products which measure the manufacturing industry of nations, Great Britain stands first, the United States second on the roll, and that there is a clear and almost identical relation between the product of coal and the product of iron. The United States now produces as much coal and iron as Great Britain yielded in 1850. We are thus gaining steadily and surely upon our great progenitor, and in the nature of things, as the population of the country grows, must, before another century rolls around, pass far beyond her possible limits of production, and become the first on the international list, because we have the greatest geographical extent, and our natural resources are upon so vast a scale that all the coal area of all the rest of the world would only occupy one-fourth of the space in which, within our borders, are stored up the reserves of future power.—*Centennial Address of Hon. Abram S. Hewitt.*

COMSTOCK BONANZAS.

IN common with all other mineral lodes a portion of the vein material of the Comstock is poor and a portion rich. When the ore is found concentrated in a large and connected body, this body is called a "bonanza." The word is similar in meaning to the terms "pocket," "shute," "chimney," "ore body," etc. Because of the great size of these Comstock ore bodies, as compared with any other known ones in the West, the Spanish term was used as something grander, precisely as "canyon" is used to speak of a deep and narrow gulch.

It is these bonanzas, says the *Mining Review*, that have been the source of both the riches and the reputation of the Comstock. If the veins were laid down flat and their area measured, it would be found that they measured about one fourth of the superficial area of the lode. Measured cubically, they compare with the solid contents of the vein as about one to twenty-five. The general form has been somewhat egg shaped, though presenting quite irregular boundaries, and their dip has been generally to the south. There appears, however, but little regularity in their formation. It must not be supposed that outside of these great ore bodies the vein is barren. Connecting them, and running through other parts of the vein, are often found smaller veins of good quartz, but owing to the gigantic scale upon which mining is carried on at Washoe few of these narrow streaks can be worked to any profit. They are good encouragers, however, and often pay nearly for their own extraction. But the many miles of drifts and shafts in the great vein that have been driven through barren ground for prospecting, ventilation, and other purposes, are evidences of the cost and labor required to find the pay, while at the same time its enormous production, as compared with the total cost, proves that the investment has on the whole been exceedingly profitable.

The following list of the bonanzas of the Comstock will be interesting to all who are watching the marvellous history of that mammoth vein:

1. Ophir and Mexican.—Discovered on the surface, and extended 500 feet in depth. Average width of ore, 15 feet; cubical contents, 112,000 tons; approximate value of ore, $22,000,000.

2. Gould & Curry.—Extended from the surface to the depth of 500 feet. Average width of ore, 15 feet; length along the vein, 500 feet; cubical contents, 190,000 tons; value of ore, $37,500,000.

3. Savage.—This was a continuation of the Curry bonanza, but not so rich. The ore continued down in the Savage claim to the very bottom of that mine, which is now 2,300 feet below the outcroppings.

4. Hale & Norcross bonanza.—This body was struck at a depth of 450 feet. It averaged 10 feet in width, was about 200 feet long, and stretched down to the 1,200 foot level. Cubical contents, 75,000 tons; value, $5,500,000.

5. Chollar Potosi bonanza—struck at a depth of 500 feet; width of the vein worked, 100 feet; has extended with but few interruptions down to the present bottom of the mine, which is over 1,700 feet. Cubical contents, 1,500,000 tons; value, $24,000,000.

6. Gold Hill bonanza.—This body extended from the surface to a depth of 500 feet, and for 300 feet on the vein. Contents, 300,000 tons; value, $10,000,000.

7. Yellow Jacket bonanza.—Discovered on the surface and extended downward for over 700 feet. The ore on this

body was quite poor, and never yeilded much profit. Its total production was about $5,000,000.

8. Kentuck bonanza—300 feet long, 20 feet wide, and 400 feet deep. This ore was very rich. Contents, 100,000 tons; value, $10,000,000.

9. Crown Point and Belcher bonanza.—Discovered on the 1,400 foot level and extended downward for 600 feet. Is still producing in the Belcher. Contents, 1,500,000 tons; value, $50,000,000.

10. Consolidated Virginia and California bonanza.—This last and greatest ore body which the lode has yet developed, was found by drifting eastward from the 1,500 foot level into what was supposed to be the last country rock. The bonanza lies above and below this, and is believed to contain $140,000,000. It extends for about 700 feet along the vein, is 600 feet in height and nearly 100 feet in width. Up to the present date it has yielded over $30,000,000, though discovered less than two years ago, and is now producing at the rate of $120,000 per day.

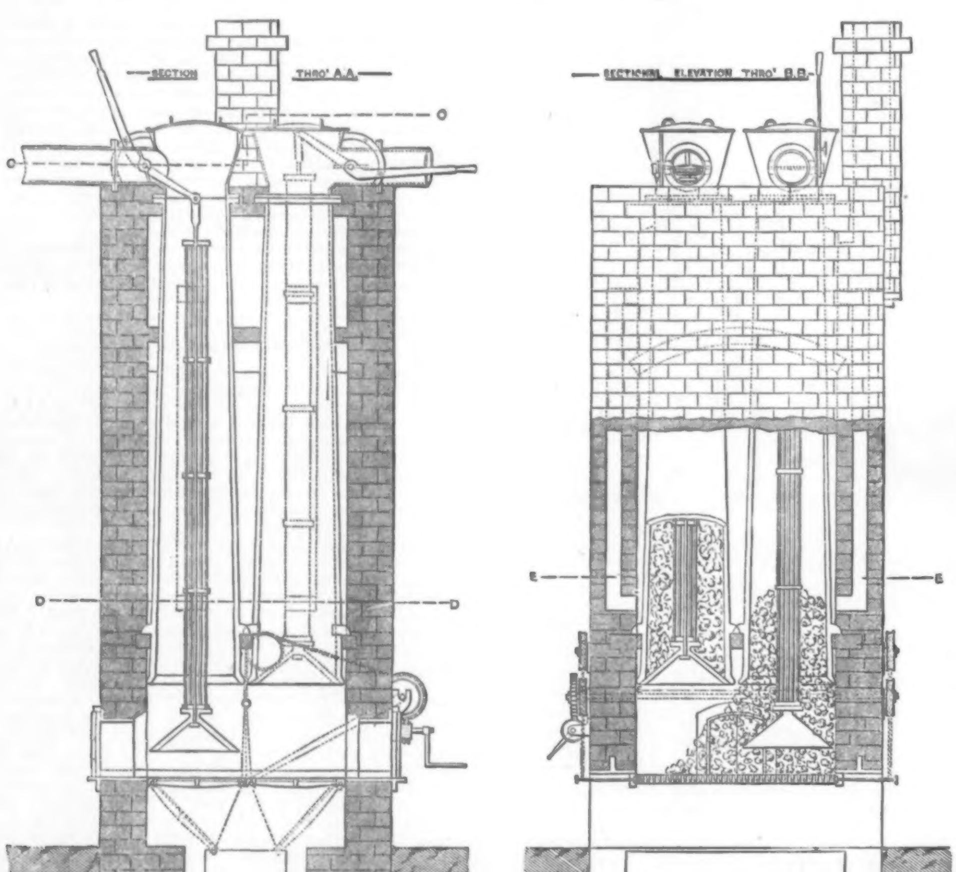
The Comstock now furnishes employment for over 2,000 miners. Its daily output of ore is nearly 2,000 tons, and its yield this year will approach $50,000,000. One half of this (or, more correctly, about 42 per cent.) is gold, and the balance silver. When the amount of ore now in sight is taken out, the lode will have produced in all something over $300,000,000 in precious metals.

VERTICAL RETORTS FOR SHALE AND OTHER MINERALS.

WE illustrate a new and highly successful method of distilling shale, coal, and other minerals, by G. Bennie, of Glasgow, Scotland. The general principle involved is very simple. The author uses a set of long vertical retorts, preferably four, Figs. 1, 2, 3, and 4, page 904, made slightly tapered or conical from the throat or neck of the charging filler at top to the larger discharging mouth at bottom. These are arranged in pairs, parallel transversely, and as close as their hoppers or flanges will allow within a rectangular heating chamber, with the lower mouth some considerable distance above a se. of hinged furnace bars below each pair of retorts, and sufficiently above a transverse passage to allow boxes on wheel frames to receive the ashes and remove them as shown.

The lower mouth of each retort is closed by a mouthpiece attached to the lower end of a long central rod, having its upper end jointed to the free end of a lever keyed on to the center of the spindle of the gas outlet valve, and worked within the top of the retort and throttle valve branch by a hand lever, so as to set and hold the lever by a spring catch and notched segment in any desired position to keep the discharge door close and the gas outlet valve open, or *vice versa*. This lower lid and rod carry a hollow tube concentrically round the rod, and rings made open or perforated at top, and closely perforated with holes all round from end to end; or otherwise this hollow tube may be made of a set of six or more long rods as a frame, covered with open or wide meshed wire cloth, or wire spirally wound in reverse directions round the rods, to form interstices through the hollow or lattice tube, which allows the gases as they are evolved from the shale or other material being distilled at any part of the retort to pass freely into and up through the hollow tube to the top, whereas in other retorts they escape through the outlet branch and pipe. The use of this hollow cage is the great feature of the invention, permitting, as it does, the free escape of gas from all parts of the charge. Each retort is fitted at top with a closing and charging door or lid, made gas tight by an annular edge projecting down from its under outer edge into a groove formed in the top rim or lip of the hopper mouth; these being jointed gas tight by fire clay or other soft or liquid luting material.

The retorts are charged full of the broken-up shale or other mineral into the annular space between their inner surface and the open central gas conducting tube from the bottom to the top of the latter, and are then heated through from the outside by the heat generated within the chamber at first by coal, coke, or other fuel charged on to the hearth through the furnace mouth and closing doors in the middle of the opposite sides of the brickwork, and afterwards either wholly or partially by the residuary hot ash and solid unconsumed carbon discharged at outlet doors of the retorts after the hydrocarbon or oleaginous gases have all been distilled over; but when these residues are not rich enough in carbon to so heat the chamber and retorts, they may be assisted from time to time by a charge of fuel through the closed doors before mentioned.—*The Engineer.*



VERTICAL RETORTS FOR DISTILLING SHALE AND OTHER MINERALS.

THE SECOR PROCESS FOR GOLD AND SILVER.

THE ordinary method used to extract gold and silver from their ores is by crushing in a mill, and then amalgamating. But, as in the placer mines, where what is called float gold generally escapes the rifles, so in quartz mining, should the ore contain free gold at all, there must be more or less float in the pulp as it comes from the stamp, and this is lost in the amalgamating pans. This float gold is so exceedingly light and thin, being more like gold leaf than anything else, that it has practically no weight, and will not sink to where the mercury has been put. As all gold ores carry more or less free gold, even though they are composed of sulphurets, chlorides, and the like, there ensues a loss in milling which amounts to no small sum in the course of a year. It has been estimated that the loss of the Comstock mines from this cause alone was between two and three millions per year. As might be supposed, efforts have been made to counteract this and to save the metal. The idea of introducing superheated steam into the pans, vaporizing the mercury, and sending that vapor through the mass was tried, and found to answer well as far as the float gold was concerned, for the mercurial vapor would come in contact with the metal and form an amalgam at once. But with such treatment the great mass of the gold would not be caught, and it was therefore necessary to treat the pulp a second time in the open pans with the mercury in a metallic state in order to save this. This double process was too expensive to be profitable, and so the use of superheated steam was discontinued.

According to the process invented by Mr. Chas. Secor, the crushed ore is put in a machine resembling a covered pan. The first introduction of steam is at about 80 lbs. or 90 lbs. pressure, which heats the mercury, and sends it through the entire mass, and takes up all float gold; the steam is then turned off for awhile, and re-introduced at a lower temperature, just sufficient to warm the mercury and cause it to combine with the metals. From 90 to 96 per cent. of the assay value is saved by this process. The machine itself is a strong iron closed cylinder containing a series of mullers, which keep the ore constantly agitated. The object of disintegrating the ore by the steam is to thoroughly prepare the charge for amalgamation, and the pressure and the degree of heat that accompany it are put on according to the general character of the ores to be treated. After being worked for one or two hours at the high pressure required, the steam is shut off, and the pressure reduced through a pipe for that purpose. Quicksilver is put in the charge, everything made tight, and amalgamation commences, and ends in one or two hours. When finished, all is discharged into settlers, and a new charge put immediately into the machine. Work is going on all the time, for while cleaning up the settler more ore is being treated. The treatment of ores does not necessarily take the length of time mentioned, but varies according to the class. Some ore can be charged in the machine and thoroughly treated as above in one hour and a half. For saving very fine gold in ores, gold that floats and cannot be precipitated, it can be easily understood that in amalgamation the heat of the steam agitates the quicksilver, the mullers carry it up in the charge, bringing it in perfect contact with the metal it is searching for. In treating a sulphuret, a pressure of 60 lbs. is put on to thoroughly disintegrate, decompose, desulphurize, or drive off the sulphate that holds the gold a prisoner. That effected, amalgamation is easy. A very heavy sulphuret will have to be roasted prior to amalgamation by this method, but it will not be necessary to crush the ore fine before roasting. Desulphurizing in a common limekiln furnace, the ore, broken to the size of an egg, is all that will be required, and ore in this way can be roasted in large quantities.

It is stated that very base ores can be treated by the Secor process raw, and made to yield about 70 per cent. of fire assay, but with the assistance of a plain fire treatment in addition the yield will be sufficient to satisfy all reasonable men. With silver ores this treatment is the same, except the very moderate use of chemicals, the cost of which is very much less than in the ordinary open pan process. The supposition is, that gold is mechanically combined in the ore; silver, with exceptions, chemically combined with other metals or minerals in the ore; hence, the use at times of the addition of fire treatment and chemicals for the successful working and yield of silver ores by an amalgamating process. The quantity of steam used in this machine is merely nominal, the steam once through the pulp with the first pressure on is the largest supply wanted. The continuation of the pressure through the pipe is to supply the trifling amount of steam that condenses. Mr. Secor does not claim to treat all kinds of ore by this method, but tells us that the class of ores he can and has worked successfully with good yield is sufficient to handsomely remunerate him. He says that the process will enable parties to work low grade ores at a cost that will yield a profit, and that mine owners can have the ores from their mines worked in quantities of from 5 to 10 tons before purchasing the machines.

CASTING STEEL.

IN the ordinary method of casting ingots and other articles of steel and homogeneous iron the casting produced is unsound, in consequence of the great rush with which the molten metal is precipitated from the ladle into the mould, the descending stream of metal carrying with it a quantity of air, which is in part retained in the casting, thereby communicating to it a greater or less porosity. Instead of pouring the melted metal from the converter of furnace directly into the mould, Messrs. Wright, Smith & Butler, of Panteg Steel Works, Monmouth, Eng., propose to pour it into an intermediate vessel or channel, whereby the height of the vertical column of melted metal entering the mould is diminished, and the rapidity of its motion lessened, and there is, consequently, little tendency in the column of melted metal to carry down with it the air which gives porosity to the casting. They construct a horizontal channel, by preference of iron, lined with loam or brick. This channel is situated over the moulds in which the casting is to be effected. A hole capable of being closed by a plug or stopper is made in the bottom of the said channel over each of the moulds. The melted iron or steel is either allowed to run from the furnace or converters into a ladle, and is allowed to run out of the said ladle into the channel described; or it is allowed to run direct from the furnace or converter into the said channel. The melted metal passes from the said channel into the ingot moulds in gentle streams, carrying little or no air with it into the casting. As the moulds fill, the openings in the channel through which the melted metal has passed into them are respectively closed by means of clay stoppers, and

the melted metal is thereby shut off. Besides the advantages already enumerated, the invention has the additional advantage that the inconvenience and loss which attend the running or leaking of the ladle when its contents are poured directly into the mould are wholly or in great part avoided by the use of the channel described.

SAND IN IRON.

LORD PALMERSTON'S definition of dirt as "matter in the wrong place" is of very wide metaphorical application. It is applicable to the presence of silica in iron, which, speaking generally, is sand in the wrong place. In one form or another sand is found in most of our minerals; it is certainly dispersed throughout our coal and limestone seams, and it is combined with our iron ores. It is so refractory that it is not to be got rid of by the process of calcining either in the open or closed hearth, and it passes as a constituent of the coke, the lime, and the iron ore into the blast furnace, where it is impossible to wholly expel it, for it holds possession as silicon. The puddler and the other operators in the forge and the mill have to do battle with it, when it is desired from the pig to produce wrought iron of first quality as a malleable product. True, its presence will contribute to the making of a quality of sheets suitable, for example, to the making of cut nails, or strips for making gas tubes; indeed, will help to make puddled steel, for it has a tendency to deposit carbon, but when we have said this we have pretty much exhausted the category of good service which in iron making silicon is capable of rendering. The benefit of its services, it will be seen, is hardly more than negative in the best of cases, since the value of nail sheets and tube strip is only trifling.

It should not, therefore, be surprising that ironmakers should generally desire to rid themselves of the ingredient. Blast-furnace proprietors would gladly rid themselves of it in other than exceptional instances, but how to succeed is not clear, so far as the ingredient is part and parcel of the pig. Less difficult, however, would be the attempt to cleanse the surface of the pig from the presence of sand. In truth, in this there is no practical difficulty. For silica as an incrustation upon pig iron the sand bed into which the contents of the blast furnace is tapped is responsible. Running the molten iron of the blast furnace into sand, thereby to shape the pig, is a practice which, though of very extensive application, would be more honored in the breach than the observance. It is impossible but that the iron must pick up considerable quantities of sand, and thereby become seriously polluted. It is within the experience of men who use such iron in the forge and mill that the pollution may occasionally be calculated at 1 lb. of sand to 1 cwt. of raw iron. Silicon is a hungry ingredient in the furnace, and when it exists to the extent inseparable from such proportions as are here indicated, it satisfies its hunger at a great price to the proprietor of the iron. Good metal escapes in gas up the stack, whilst more is otherwise destroyed, to the increasing of the bulk of the refuse cinder. Nor must it be supposed that, because the output of the furnace is sometimes greater in the stage in which it is placed upon the puddled bar back, that, therefore, silicon has not exerted its wonted influence. The greater weight not unfrequently obtained from a charge of iron notoriously impregnated with silicon, as compared with the weight obtained from clean and pure iron like the high-class products smelted from the best claystone of South Staffordshire has resulted from the impoverishment of the fettling of the furnace, and oftentimes from the devouring of a scrap bottom in one heat, whilst at every subsequent stage of manipulation the iron made from the poorer puddled bar loses a much greater proportion than that made from the pig iron which yielded less in the puddled bar, but did not rob the fettling nor destroy the furnace bottom.

The theme was some time ago ably discussed by foremost ironmasters in the Cleveland district, and it is now being taken up by the practical ironmakers of South Staffordshire, Eng., where the Forge Managers' Association have had one discussion upon it, raised by one of their number, and they are stated to have had so much to say upon it that it was found expedient to adjourn the debate. The remedy of the evil consists in that which the leading ironmasters pointed out—the tapping of the blast furnace into chills of iron, and not into beds of sand. Doubtless, the first cost of chills would be much greater than of sand, but it is not clear that in the long run the employment of chills would not prove as economical as the use of sand beds; for, when the chills had become worn out, they would be capable of being used up, either in the blast furnace itself or in the refinery, whilst the improvement in the purity of the pig would increase the market value of the iron. Mr. I. Lowthian Bell has spoken upon the great economy which would follow upon the elimination of phosphorus from Cleveland iron, and the transmuting of it into phosphoric acid. The day is not very remote when it will be resolved to further economize the refining of iron in the forge and the mill by the shaping of raw iron in chills and not in sand beds; and when that has come about, puddlers will be deprived of sources of complaint pregnant of much dissatisfaction and ill-feeling, and many thousands a year will be saved in the British iron trade.—*Mining Journal.*

NEW BRONZE SATYR.

THE trustees of the British Museum have recently purchased from MM. Rollin and Feuardent, of Paris, a bronze figure of a Satyr, remarkable for its beauty and fine condition. The Satyr is represented drawing back in an attitude, apparently, of surprise. The weight of his body has rested principally on the great toe of his left foot; the right heel is raised; the toes of this foot just touch the ground. His left arm and hand are stretched in an oblique direction; his right arm is bent, the hand raised towards the head. He has a flowing beard; behind his right ear is a small budding horn, but no trace of a corresponding horn can be seen behind the other ear. In the hair are small holes in which a wreath has been fixed. The attitude and type of this figure at once reminds us of the Satyr in the Lateran Museum at Rome, which Brunn supposes to be part of a group representing Athene and Marsyas as they are represented on an Athenian relief, and a coin, also of Athens. This group was the subject of a work in bronze by Myron. (See Brunn, in *Instit. di Corr. Archeol.*, Rome, 1857, pp. 374–383, and *Monum.* of the same work, vi. Pl. 23.) It will be seen, on comparing the new bronze with the statue and group engraved in the plate of the *Monumenti*, that in the Satyr recently acquired by the Museum, the position of the right arm and of both legs does not correspond. But the arms of the Lateran statue are restorations, and it is quite possible that their original direction may have been the same as in the bronze. The variation in the relief and the coin is no more than might be expected when a group in the round is carelessly repeated in relief on a much smaller scale. The style of the modelling in the new bronze, and the length and wiriness in the type, remind us of the Satyrs in the frieze of the Choragic Monument of Lysikrates, and of the male figures in the frieze of the Mausoleum, much more than of any extant sculpture of the age of Phidias. We are, therefore, justified in saying that the new bronze presents the characteristics of the school of Skopas rather than those of the school of Myron. The hair and beard of this bronze are very delicately wrought, and the muscles of the body, and especially of the back and shoulders, admirably rendered. The spirit and vigor in the general motive and in the expression of the countenance recall to us the the epithets *vivida* and *animosa*, by which Roman critics characterized the works of Myron and also of Lysippus. The right foot exhibits so marked inferiority in the modelling to the rest as to suggest the notion that it was anciently restored by an inferior artist. The bronze is in admirable condition, having only lost the great toe of the left foot and part of the forefinger of the left hand. It is two feet six inches high, about the same height as the Towneley Hercules. Nothing certain is known of its *provenance*, but it is said to have been found in an ancient *cloaca* at Patras.—*Academy.*

PALLADIUM IN ALCOHOL FLAME.

PALLADIUM held in an alcohol flame is rapidly covered with carbon. The author, F. Wöhler, supposed this to be due to its affinity for hydrogen, but finds by experiment that palladium does not decompose ethylen and the various gases of the alcohol flame below a red heat, although below the decomposing temperature of ethylen. He suggests the possibility of a temporary absorption of hydrogen, as in the case of copper heated in ammonia gas.

BEERIZING TIMBER.

AT a recent meeting of the Liverpool Architectural Society, Mr. W. E. Hughes (of Messrs. Joseph Pierce & Co., Regent road, Canada Dock, Liverpool), read a paper on "The Seasoning and Preservation of Timber." The process is known as "Beerizing timber," and takes its name from Sigismund Beer, a chemist of New York City, who discovered that by the use of borax as a solvent the coagulation of sap is prevented, and this without injury to the wood tissues. The obnoxious ingredients being thus removed, the wood is rendered closer in grain and thereby improved in appearance, becomes impervious to decay, and perfectly indifferent to atmospheric changes. The process, which was fully explained by Mr. Hughes, has been patented, and Messrs. Pierce & Co. possess the sole right of using it in this country. Mr. Hughes exhibited specimens of the "Beerized wood," some of which had been in use in coal mines. A long discussion followed the reading of the paper, in which all spoke of the process, which is only a new one, as of the greatest importance. Mr. Thorburn, in moving a vote of thanks to Mr Hughes for his paper, remarked that all previous processes for preserving wood had been failures, and this new system must have their entire sympathy.—*London Building News.*

ON ANTHRACEN TESTING.

By R. LUCAS.

OF all the anthracen tests which have been published, Messrs. Meister, Lucius & Brüning's "new and improved test" (*Chemical News*, vol. xxxiv., p. 167) treatment of the quinon with fuming sulphuric acid, &c., comes the nearest to the truth. The anthraquinon obtained by this test is not chemically pure, and Meister, Lucius & Brüning stipulate, therefore, to volatilize the product obtained and to deduct the carbon and ash from the weight of the anthraquinon, and only the volatile part represents the pure anthraquinon. The volatilization of the quinon is objectionable, because it is very difficult to volatilize the anthraquinon completely without burning some of the carbon. Chemically pure anthraquinon can be volatilized completely without leaving a mark if heated carefully, but if it is heated too quick and some drops of the anthraquinon fall back on the heated bottom of the crucible some carbon remains.

To overcome this difficulty of volatilizing the quinon, and to make the test more exact, I propose the following alteration and addition to Messrs. Meister, Lucius & Brüning's new test. Instead of volatilizing the quinon, I dry it on the filter and treat it again by the anthraquinon test with chromic acid. The whole test would now read as follows:—

Take 1 grm. of anthracen, place it in a flask of 500 c.c. capacity with upright condenser, add to it 45 c.c. of glacial acetic acid, and heat to ebullition. To this solution (which is kept boiling) add, drop by drop, a solution of 15 grms. of chromic acid in 10 c.c. of glacial acetic acid and 10 c.c. of water. The addition of the chromic solution should occupy two hours, after which the liquid is to be kept boiling for two hours longer, four hours being required to complete the oxidation. The flask with its contents is to be kept standing for twelve hours, then mixed with 400 c.c. of cold water, and again kept standing for three hours. The precipitated anthraquinon is now collected on a filter and washed, first with pure water, then with boiling dilute alkaline solution, and finally with pure water. The quinon is now washed from the filter into a flat dish and dried at 100° C. It is then mixed in the same dish with ten times its weight of fuming sulphuric acid (sp. gr. 1·88) and heated to 100° C. for ten minutes on a water bath. It is then taken at once from the water bath and kept in the same dish for twelve hours in a damp place to absorb moisture. Then add 200 c.c. of cold water to the contents of the dish, collect the precipitated quinon on a filter, and wash, first with pure water, then with boiling alkaline solution, and again with pure hot water, and finally dry.

The quinon is now removed from the filter and put into a flask of 500 c.c. capacity, and the small quantity of quinon remaining on the filter paper is washed off with 45 c.c. of hot glacial acetic acid into the same flask. Now heat to boiling and add slowly a solution of 15 grms. of chromic acid in 10 c.c. of glacial acetic acid and 10 c.c. of water and boil for four hours. The flask with its contents is kept for twelve hours, then mixed with 400 c.c. of cold water, and again kept standing for three hours. The precipitated anthraquinon is now collected on a double filter, and washed, first with pure water, then with boiling dilute alkaline solution, and again with pure water, and finally dried at 100° C. until constant in weight. The weight of the quinon obtained is to be calculated in the usual manner into anthracen. The quinon obtained should always be tested for ash, and the weight of the ash deducted from the weight of the quinon before calculating it into anthracen.

A few words about anthracen might be interesting to tar distillers. Some people believe that anthracen showing a low percentage is identical with a low quality anthracen, and that a high percentage anthracen must always be of good quality. This is an error. Some tar distillers push the distillation of the tar or of the anthracen oils too far and they get an anthracen of inferior quality, because it is principally the last portion of the distillate containing the so-called pitch anthracen, which is of inferior quality, and some of the alizarin makers stipulate, therefore, in their contracts "the anthracen must not be made from pitch." My experience is that anthracen of bad quality cannot be improved by simply pressing, and that the quality is not always improved by washing with solvents. But the quality of inferior anthracen is improved (1) if the anthracen in question has not been filtered and pressed by a re-distillation of the same, leaving the last portion as pitch in the still; and (2) if the anthracen has already been pressed by a systematical recrystallization from solvents.—*Chemical News.*

GLAUBER'S SALT AND ITS USE IN WOOL.

NEUTRAL sulphate of soda is known in the trade as Glauber's salts, and is sold in the state of large white crystals. Certain remarkable chemical properties make it valuable in woollen dyeing. By combining with acid, the neutral sulphate is transformed into bisulphate, and this property has a great value in a tinctorial point of view.

Orchil paste, the red woods, turmeric, madder, logwood, and fustic are only absorbed by wool to a very small extent in presence of a dilute acid, but if sulphate of soda is added, a great part of the acid combines with the soda, and the tinctorial matters employed are fully utilized.

With soluble indigo, the same agent gives an equally good result on an opposite principle, by preventing a too rapid and uneven exhaustion of the beck.

The solubility of neutral sulphate of soda presents a singular anomaly. At 32° Fahr., 100 parts of water only dissolve 5 parts of the sulphate; the solubility then increases rapidly and attains its maximum at 90° Fahr., when 100 parts of water only dissolve 322 parts of the salt. At higher temperatures the solubility lessens again.

The following receipts have given good results on woollen piece goods:

GREENISH BLUE.

Alum	5,040	parts.
Soda crystal	420	"
Soluble indigo	175	"
Sulphate of soda	1,680	"
Flavine	17½	"

BILLIARD GREEN.

Alum	8,400	parts.
Sulphate of soda	5,040	"
Soluble indigo	1,680	"
Picric acid	350	"

Heat to 167° F. for half an hour.

LOGWOOD BLUE.

Alum	8,400	parts.
Chromate of potash	1,120	"
Blue vitriol	560	"
Argol	2,240	"
Glauber's salts	6,720	"
Sulphuric acid	2,240	"

Boil for 1½ hour, and then add 22,400 parts of logwood.—H. Soderstrom.—*Le Teinturier Pratique.*

METHYL GREEN ON WOOL (22 LBS).

MAKE up a beck with 4 lbs. 6 ozs. hyposulphite of soda, 2 lbs. 3 ozs. alum, and 17½ ozs. sulphuric acid. Enter the wool at 144° Fahr., and work for 1½ hour, raising the heat gradually to 178° Fahr. Take out and let lie for several hours. Then rinse, and enter in a fresh beck, at 122°, containing the necessary amount of methyl green, 7 ozs. acetate of soda, 10½ ozs. borax, and if needful, ½ oz. to 1 oz. picric acid. Raise the temperature gradually to 178° Fahr. in 90 minutes, cool well, rinse, and dry slowly.

Or (for the same weight of wool) wash the wool in a soap beck and rinse well. Prepare a beck with 2 lbs. 3 ozs. hyposulphite of soda, and 17½ ozs. (weight) of spirits of salts; heat slowly to 189° Fahr., and work the wool for 75 minutes. Let the wool lie for twelve hours, rinse well, and dye at 167° to 200° Fahr. with a quantity of methyl green, suiting the shade.

Metal must not be allowed to come in contact wth the dye-liquor, and the process must therefore be conducted in wooden becks. The steam pipe must be made of stoneware, glass, or vulcanized caoutchouc.

The color recommended is the soluble methyl green of the Berlin "Joint Stock Company for Aniline Colors." One part of the color is put into 20 parts of warm water, at 144° Fahr., stirred till dissolved, let to cool, and filtered.—*Muster Zeitung.*

CACHOU DE LAVAL.

ACCORDING to a series of experiments lately executed, this patent color gives very valuable results. Fifty grammes (1¾ oz.) of the color, to 35 fluid ounces of water, give a very useful shade. The fixing bath to follow after consists of 75 grains bichromate per 35 fluid ounces of water. A dye bath containing only 45 grains of color to 35 ozs. water, and a subsequent passage through chromate of potash, give a light gray with a yellowish cast. If 150 grains of the patent color are dissolved in water, and mixed with ¾ oz. catechu, previously dissolved in 150 grain measures of caustic soda lye of specific gravity 1·208, and 17 ozs. water, and the whole made up with water to 35 ozs., cotton yarn when worked in this liquid for 15 minutes at 167° Fahr., and then taken through a chrome beck, takes a deep, full bronze. The shade is deeper if taken through weak aquafortis at 2° B., instead of chrome. The tone of these colors is very pleasing. The "patent color" can also be advantageously combined, giving a full catechu tone with a strong reddish cast, especially if taken subsequently through aquafortis. The fixing bath has a great modifying influence upon the resulting colors. Bichromate of potash gives, as a general rule, the darkest tones; nitric acid and nitrate of iron give a yellowish gray, whilst a weak bluestone beck, say ½ oz. to 35 fluid ounces of water, give a gray with a blue shade. Hence the "patent color" may serve as a cheap ground for indigo. For this purpose the white yarn is first dyed with cachou de laval (45 to 75 grains of color per 35 fluid ounces of water), then taken through the bluestone beck, washed, dried, and tapped in the vat in the ordinary manner. There is thus a considerable saving of indigo, without impairing the fastness of the color.—*Dingler's Polytechnic Journal.*

ON THE ARTIFICIAL COLORING MATTERS DERIVED FROM COAL TAR.

By PROF. ADOLPH WURTZ.

NO SERIES of discoveries has been made of late years which indicates more strikingly the influence of pure science on the progress of the practical arts, and those which it is proposed to describe in the following lecture. They relate to the formation of a great number of coloring matters which rival in brilliancy the most beautiful hues offered by nature, and which, by a marvellous effort of science, are all derived from a single material—coal tar. What a contrast between this black grimy product and the pure substances which may be obtained therefrom and transformed into pigments, which, when dry, possess an iridescent brilliancy like the scales of cantharides, or in solution present the brightest tints of the rainbow! Their coloring power is immense, as experimental proof demonstrates. Here are some leaves of white paper upon which I have sprinkled the coloring matter in finely pulverized state. The powder is so fine, and the quantity applied so small, that the whiteness of the paper is scarcely dimmed. I pour on a little alcohol to dissolve the substances, and immediately there appear intense and magnificent shades of purple, blue, violet, green and rose.

All these matters are chemical species well characterized. Their composition has been determined, their mode of formation, their inter-relation, their properties are all known. Their chemical history is almost complete, but it is difficult, and it may fairly be stated that their study has been one of the most arduous problems of organic chemistry.

Coal tar is one of the products of the distillation of coal in closed vessels. This operation yields illuminating gas and various products which condense in liquid state, and which are a water charged with ammonia and tar, the latter separating in the form of a thick black liquid. The residue of the distillation is coke.

The tar is a very rich mine of organic substances, which may be separated, and each of which has a distinct individuality, and is of species apart from all others. I have found that up to the present time forty-three such substances have been extracted. All of these bodies it is not my purpose to mention, and shall only refer to such as form the bases of coloring matters:

We have first the carburets of hydrogen, so named because they are composed of but two elements—carbon and hydrogen. Some are gaseous, some liquid, some solid. Among the liquids are benzine, which is generally well known, and toluene, which M. Deville previously found in the products of distillation of tolu balsam. The solid carburets are naphthaline, which crystallizes in brilliant plates, and anthracene. In another body, well known for its antiseptic properties, phenol, a third element oxygen is added to the carbon and hydrogen. Lastly there is aniline, a basic body, capable of neutralizing the acids, after the fashion of ammonia, to form with them true salts analogous to the ammoniacal salts. Like ammonia, aniline contains nitrogen, which is associated with the carbon and hydrogen, and aniline constitutes the most precious material for the fabrication of artificial colors.

The extraction of these substances is accomplished by submitting the coal tar to distillation in huge cylindrical boilers. The tar is at once separated into different parts or fractions, which are then submitted to special treatment. These products differ from each other in their degree of volatility, that is to say, in the facility, more or less great, with which they enter into ebullition and vaporize on being heated. Thus benzine, more volatile than water, distils over below 212° Fah.; toluene above at 231°; phenol at 366·8°; naphthaline, 413·6°; and anthracene at 680°. If then a mass of tar containing all these products be heated, they will distil successively as the temperature rises, the more volatile ones first, the least last, and the others by intermediate degrees. By collecting separately the different portions, it is thus possible to separate the products of different volatility. This process is called fractional distillation.

Applied to the separation of the products contained in coal tar, the operation furnishes:

1. The oils or light essences of tar which pass over below 293° Fah., and which are rich in benzine, in toluene and other analogous carburets. The different tars furnish variable quantities of these products, which rarely exceed 3 per cent. of the weight.

2. The medium and the heavy oils next pass, the first between 293° and 424°, and the others between 424° and 636°. The latter are the most abundant products of the tar, which yields some 20 per cent., and they are still rich in hydrogen carburets. Naphthaline is here met with, and also some phenol and aniline.

3. The anthracene or fatty green oils, so called because after cooling they present an unctuous consistence and greenish hue, follow. They distil between 636° and 848°, and contain that solid hydrogen carburet known as anthracene which serves as a base for the artificial preparation of alizarine.

The residue in the retorts after all the oils are distilled is pitch. This is usually run into basins and cooled, and is principally employed for the manufacture of conglomerate pavements, etc. I am obliged to omit mention of the special processes by the aid of which the isolation and purification of the coal tar products is effected on account of the abundance of technical details. But in lieu thereof we may glance at some scientific ideas regarding the composition and the properties of the chemical substances which I have just named.

The first and most important is benzine. When it is perfectly pure, at a low temperature it resolves itself into a mass of crystals, fusible at 41° Fah. It is formed by the union of six atoms of carbon with six atoms of hydrogen, all of these atoms being grouped and combined to form a single molecule of benzine, as shown in Fig. 1. This system represents a stable combination. The carbon atoms attract the hydrogen atoms as a planet attracts its satellites, and equilibrium is maintained in this little world so long as each atom remains in the sphere of attraction of its neighbors. If a single atom of hydrogen be removed, for example, the equilibrium will be destroyed.

It is possible, nevertheless, to remove one (or several) hydrogen atoms in the group which represents the benzine molecule, but under the condition of replacing it by another element or atom which is equivalent to the hydrogen atom. Thus I may displace one of these six atoms of hydrogen, which we will consider as represented by six white balls, by an atom of chlorine represented by a yellow ball. Nothing is now changed in the system, so far as the number of elementary atoms is concerned. We still count over six carbon atoms represented by black balls, five atoms of hydrogen, and in place of the sixth the chlorine atom, which we have substituted. This, in fact, is a case of "substitution," and the possibility was first discovered by M. Dumas.

Now, instead of replacing an atom of hydrogen by a simple body, such as chlorine or bromine, we may substitute a group of atoms acting as a simple body. This requires explanation, and the details into which I am about to enter now form the nucleus of the scientific question relative to our subject:

Here is a gas, the most simple of all the compounds of carbon and hydrogen. It is called light, carburetted hydrogen, and sometimes marsh gas or fire damp. It contains but one atom of carbon and four atoms of hydrogen. When one of the hydrogen atoms is removed, the carbon atom, which is capable of attracting and fixing four, has its affinity for hydrogen unsatisfied. It will no longer remain saturated, so to speak, and the remainder composed of one atom of carbon and three atoms of hydrogen will tend to combine anew with one hydrogen atom, or its equivalent. The removal of the hydrogen atom will then have developed in the remainder a force of combination which is equivalent to that residing in one hydrogen atom. If, from a molecule of benzine a hydrogen atom be removed, this new remainder formed of six atoms of carbon and five of hydrogen, will be in the same state and it will possess a like combining capacity. Here, then, we have two remainders—one, marsh gas, which, minus one atom of hydrogen, is called methyl—the other benzine, less one hydrogen atom, called phenyle. Each may serve to supply a place wherever one hydrogen atom is needed, and consequently they may act mutually on each, uniting, and the one supplying the need in the other. From this combination will result methyl-phenyl, which is none other than toluene. It represents benzine, of which one hydrogen atom has been replaced by the methyl group, or if you choose, marsh gas in which one atom of hydrogen has been replaced by the phenyl remainder. It is thus that the remainders or incomplete groups, where an atom of hydrogen is wanting, may become substituted in the combinations for one hydrogen atom. The toluene we have produced, contains, as Fig. 2 shows, seven atoms of carbon and eight atoms of hydrogen. Its mode of derivation is not purely theoretical, but is proved by experiment. Toluene may be actually produced by really substituting in benzine a methyl group for one hydrogen atom. Moreover, the hydrogen of a given compound, for instance, may be replaced by other remainders or other groups than methyl or phenyl, and these remainders are engendered like the latter by the loss of one hydrogen atom.

Water is formed of one atom of oxygen and two atoms of hydrogen. If it loses one atom of hydrogen, the remainder

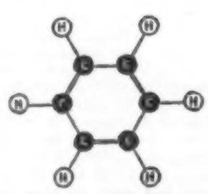


Fig. 1. — Benzine (C^6H^6).

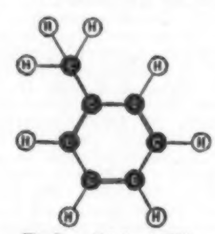


Fig. 2. — Toluene (C^7H^8).

Fig. 3. — Nitro-benzine ($C^6H^5AzO^2$).

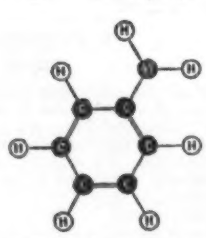


Fig. 4. — Aniline (C^6H^7Az).

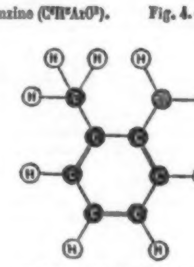


Fig. 4. — Toluidine (C^7H^9Az.)

will tend to combine anew with that hydrogen atom, and will acquire a combining capacity equivalent to one hydrogen. Now, in the same manner as already explained, this remainder formed of one oxygen and one hydrogen atom may replace a hydrogen atom in benzine. The resulting body is phenol, and I may represent its derivation from benzine by removing one of the white balls with which we represented hydrogen atoms, and replacing it by an atom of oxygen and an atom of hydrogen, represented by one red and one white ball. This process is also verifiable by actual experiment.

One more example of this substitution may still be adduced. Ammonia is formed of one atom of nitrogen and three atoms of hydrogen, a combination which I represent by one green and three white balls. If we remove one hydrogen atom, then the remainder acquires the combining capacity equivalent thereto, as already described. It may, therefore, replace an hydrogen atom in benzine, and the result is aniline or phenylamine, Fig. 4. This body exists in coal tar, but M. Zinin, a Russian chemist, has produced it artificially by the process of substitution above explained. To convert benzine into aniline, the first step is to transform the benzine into a nitrogenized derivative, with benzine, Fig. 3. This is done by treating it with concentrated nitric acid. The benzine, cold, is mixed carefully with a certain quantity of nitric acid, to which is previously added concentrated sulphuric acid. Here is the mixture which is orange red in hue, and which emits red vapors. I throw it into water and you see a dense oil separate and fall to the bottom of the water, which dissolves the excess of the acids. This is nitro-benzine. Now, what has taken place?

One molecule of benzine loses its hydrogen atom. The latter goes to form water with one atom of oxygen and one of hydrogen, which both are detached from one molecule of nitric acid which contains one atom of nitrogen combined with three atoms of oxygen and one of hydrogen. After having lost, this one atom of hydrogen and one of oxygen, the nitric acid is reduced to a remainder which contains one atom of nitrogen and two of oxygen. This remainder is substituted for the hydrogen which the benzine has lost and the body resulting from the substitution is nitro-benzine. Purified, it appears under the form of a yellow liquid, transparent, and having a fine almond odor which renders it very valuable to perfumers. It is employed, under the name of essence of mirbane, to scent soap. You see that it differs from aniline only by the fact that it contains two atoms of oxygen united with the nitrogen in the nitric remainder, while aniline contains two atoms of hydrogen united to this same nitrogen atom in the ammoniacal remainder. Replace then the two atoms of oxygen by two atoms of hydrogen, and you will have converted nitro-benzine into aniline. This replacing is easy. It suffices to submit the nitro-benzine to the action of a body capable of ceding or disengaging hydrogen for the latter to unite with oxygen, first to form water and to substitute itself for that oxygen, atom by atom.

To this end Zinin submitted nitro-benzine to the action of sulphuretted hydrogen, the hydrogen of which easily separates itself from sulphur. M. Bechamp advises that this source of hydrogen be replaced by another and more abundant one, a mixture of iron and acetic acid, which disengages hydrogen, just as does a mixture of diluted sulphuric acid and iron. In both cases an iron salt is produced.

The process just described for the transformation of benzine into aniline or phenylamine is also applied to the transformation of toluene, Fig. 2, first into a nitrogenized body, nitro-toluene, and then into a base corresponding to aniline, namely, toluidine, Fig. 5. And you see that this toluidine is itself a derivative of benzine. First, the latter is converted into toluene, by removing one hydrogen atom and substituting a methyle group, Fig. 2; then a second atom of hydrogen is removed from the benzine group which formerly contained six, and this second atom of hydrogen may be replaced by an ammoniacal remainder. All these substitutions may be realized experimentally.

We are now in possession of the first materials which enter into the preparation of a great number of aniline colors. One of the most important is the rich purple known under the name fuchsin, or called by Hofmann rosaniline. It is obtained by oxidizing aniline, or rather a mixture of aniline and toluidine. For the aniline of commerce, prepared in a certain manner and used for the purpose, is a mixture of the two bodies. The oxidizing agent used is arsenic acid, which possesses a certain tendency to lose oxygen and to become arsenious acid. This oxygen, which it loses when heated, with a mixture of aniline and toluidine, serves to remove hydrogen from the latter bodies, and water and rosaniline results.

I wish you to understand this reaction, for it is very curious, and by putting in conflict molecules, relatively simple, one of aniline and two of toluidene, it engenders a very complicated rosaniline molecule, containing all the elements of the three molecules named, except six hydrogen atoms taken from them. It is precisely this loss of hydrogen which gives place to the formation of the complex rosaniline molecule, as follows:

I take, let us suppose, a molecule of aniline, which is represented in Fig. 4. I dispose besides this aniline, two molecules of toluidine, so that the three molecules in some way touch each other. I take away now one atom of hydrogen from a certain carbon atom of the aniline molecule. This carbon atom will no longer be satisfied in its affinities. Similarly I remove one hydrogen atom from a certain carbon atom of the toluidine molecule. Like the other, this carbon atom will be similarly unsatisfied. Therefore the loss will have developed in each one of those carbon atoms a force by virtue of which they unite one to the other to contract a solid union. There we have joined the molecule of aniline to one toluidine molecule. Now from the latter I take away a second hydrogen atom, and at the same time I remove a hydrogen atom from the second toluidine molecule, for we have two such. The two carbon atoms thus despoiled unite, and thus we have a union between the toluidine molecules. Lastly, the second toluidine molecule, losing a second hydrogen atom and the aniline molecule (which thus far has lost but one atom), losing now a second one in its turn, a union between aniline and toluidine molecule results. Thus by the loss of six atoms of hydrogen, and through the force of combination developed by that loss, the three molecules, at first free and mutually independent, have been obliged to unite in order to constitute a single group, stable but complicated, for it contains twenty atoms of carbon represented by twenty black balls, nineteen atoms of hydrogen indicated by as many white balls, and three atoms of nitrogen, for which three green balls stand. This is rosaniline; ammonia contains in its molecule but a single nitrogen atom. It is the same with analine and toluidine. These bodies are *monamines*. Rosaniline, which contains three atoms is triamine. It is curious that, when pure, rosaniline is colorless, but the combinations which it forms with the acids, that is, the rosaniline salts, present in the crystalline state magnificent green reflection, and in the dissolved state a purple hue.

The industrial process for preparing rosaniline is as follows: In large boilers in which are mechanical agitators, are introduced 1,000 kilograms of commercial aniline and 1,500 kilograms of a solution of arsenic, acid at 15 per cent. Heating succeeds, and when this is terminated the boilers are emptied and the mass removed by boiling water. To the liquors obtained a solution of sea salt is added. Chlorhydrate of rosaniline is precipitated, for it is insoluble in the saline solution. This is purified by crystallization, and is obtained in commercial form. In order to dye with rosaniline, it suffices to dissolve a small quantity of chlorhydrate of rosaniline in hot water. Here is the solution: I introduce a piece of white silk, remove it after two minutes, wash it in plenty of water, and, as you see, it is colored purple.

With rosaniline various other coloring matters are prepared. Lyons blue (*Bleu de Lyon*) was first made by MM. Girard and de Laire, who discovered the reaction following heating with aniline, chlorhydrate of aniline, or another analogous base. The aniline or phenylamine thus added to the chlorhydrate, is converted into ammonia by gaining a hydrogen atom and losing the phenyl group. The latter substitutes itself for the hydrogen removed from the second molecule of aniline, which is thus converted into diphenylamine, and which is none other than ammonia in which two hydrogen atoms have been replaced by two phenylic groups. If the aniline or phenylamine is ammonia phenylated once, diphenylamine is aniline phenylated or ammonia phenylated twice. In the same manner rosaniline is phenylated by heating its chlorhydrate with aniline. Ammonia is disengaged, and the chlorhydrate of pheny-rosaniline thus obtained is Lyons blue, to fix which in fabrics an alcoholic solution is employed. It is rendered soluble in water by treating it with sulphuric acid.

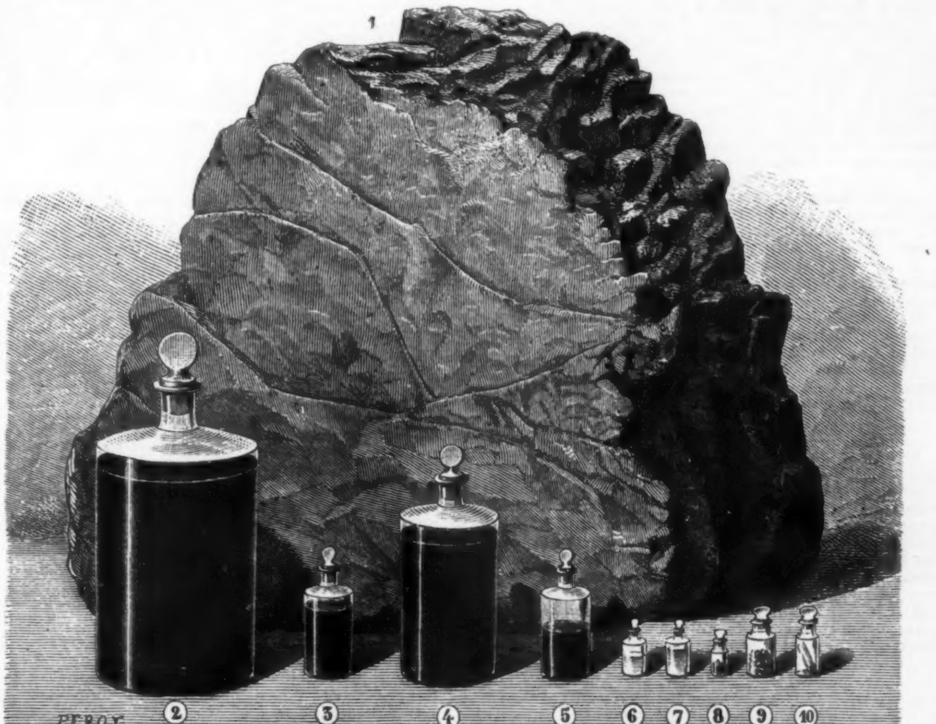
Now in the same way that we have introduced the phenyl groups into rosaniline, so can we introduce the methyl groups. These remainders exist in a variety of combinations; among others, in this gas is chloride of methyl, and which I can ignite. You see it burning with a greenish flame. It contains the methylic group united with one atom of chlorine. Here is its analogue, iodide of methyl, which is liquid, and which contains a methylic group united with one iodine atom. When this iodide of methyl is heated with rosaniline, the iodine removes hydrogen from the latter, and the methyl group substitutes itself for that hydrogen. Thus we have trimethylated rosaniline, or Hofmann's Violet, so named from its discoverer. The salts of this methylated base present a magnificent violet color, which is a valuable dye.

In order to prepare trimethylated rosaniline, we have first prepared rosaniline, and then methylated it. M. Lauth, a distinguished chemist, reverses this operation. He first methylates aniline, and then oxidizes the methylaniline by a pecular process. He thus produces directly trimethylated rosaniline, and calls the product Violet de Paris.

Trimethylated rosaniline has the remarkable property of uniting directly with chloride or iodide of methyl. According as a molecule of the former combines with one, two or three molecules of chloride of methyl, the combinations formed present rich shades of Parma violet, a brilliant green, and a violet blue. With two molecules of chloride of methyl it produces a color called "green light" (*vert lumiere*), on account of its brilliancy, and also from the fact that it keeps its shade under artificial light.

We have now obtained from aniline, purples, blues, violets and greens. The other colors, limits of space and time oblige me to summarize. There is first, aniline black, which is not properly a tinctorial color, but rather an applied shade, as it is formed and developed directly in the fibre. Recently, however, baths of aniline black have been prepared for dyeing purposes.

Safranine, as you see by this sample, communicates to silk a beautiful rose red hue. I now pass to the colors derived from naphthalene, phenol and anthracene.



COLORING MATTERS FROM COAL TAR.

Only one naphthalene color need be mentioned, and that is rosanaphtylamine, which is to napthalene as rosaniline is to benzine. It colors silk a rose shade, and its red solution presents a beautiful orange fluorescence.

Phenol and its derivates furnish a variety of fine shades. Picric acid, a nitrogenized derivative of phenol, is yellow, and communicates that color to silk. Rosalic acid is obtained by heating phenol with sulphuric acid and oxalic acid. This may be used directly, or may be transformed into a red coloring matter termed coralline. These beautiful white crystals, which I now exhibit, are resorcine, another phenol derivate. It is a near relation of phenol; and, as this latter body is derived from benzine by the addition of one oxygenation, so is resorcine derived from benzine by adding two oxygen atoms. To M. Baeyer is due the credit of heating this body with an acid which is the product of oxidation of napthaline anhydrous phtalic acid, and producing the magnificent substance known as fluoresceine. Observe the superb green fluorescence of the transparent rose colored solution of this body! A few drops of the concentrated solution which I throw into water expand into strial and clouds, which become illuminated by a green light while the liquor itself becomes a transparent. By treating this material with bromine, a gorgeous rose-red dye called cosine is produced.

But the great triumph of science in this long category of wonders is yet to be described. It is the artificial production of the red coloring matter of madder, which Robiquet has discovered and named alizarine. The history of this discovery is peculiarly instructive, and indicates strikingly the power and influence of science in the progress of modern industries. Alizarine is an oxygenated body, and, according to old analyses it was supposed to be related to naphthaline, and that it could be artificially prepared by the aid of that body. But a great number of attempts to do so proved fruitless. One day, two German chemists, Graebe and Liebermann, succeeded in obtaining alizarine, by removing all the oxygen of, and adding hydrogen, not to naphthaline, but to anthracene. It is the latter body, then, which should be considered as the carburet of hydrogen generator of alizarine; and, in order to convert it into this substance, it sufficed to remove two atoms of hydrogen, and to add four atoms of oxygen. By oxidizing the anthracene with chromic acid, it is first converted into magnificent yellow crystals called anthraquinone. This substance contains two atoms of hydrogen less than anthracene, plus two oxygen atoms. To transform it into alizarine, four other atoms of oxygen must be added. This was done. And the alizarine appeared in beautiful red crystals. Thus obtained by synthesis, it is identical in all respects with the alizarine extracted from the madder root.

This dye-stuff is used in the coloring of wool and cotton. Here are specimens of cotton dyed red, violet, and black by alizarine, according to the nature of the mordant which impregnates the places at which the coloring matter is fixed. Raw cotton, to receive the dye, must first be impregnated with acetate of aluminum, acetate of iron, or both. In the samples exhibited are bands of red, violet, and black. The first received the acetate of aluminum mordant; the second, a mixture of acetate of aluminum and acetate of iron; and the third, acetate of iron alone.

The remainder of M. Wurtz's admirable lecture is a brief summary of the foregoing, and may, therefore, here be omitted. We add an engraving below, extracted from *La Nature*, which represents a block of block of coal, weighing 220 pounds, and beside it the proportional volumes of the products obtained therefrom, drawn on a scale of ⅛ natural size. 1, is the coal block; 2, tar; 3, light oil; 4, heavy oil; 5, anthracene oil; 6, benzine; 7, toluene; 8, phenol; 9, naphthaline; and 10, anthracene.

ACTION OF WATER ON GLASS.

THE author, A. Franck, finds glass of the following composition best suited to resist the decomposing influence of steam—$_3K_2O_3CaO_{14}Sio_2$. An easy method to determine the value of glass in this respect is to boil a finely pulverized sample for some time with water, and notice the decrease in weight. This amounts in some instances to 10 per cent.

WOOL AND COTTON IN YARNS.

HERR K. J. BAYER communicates the following method for the determination of the amount of wool and cotton in yarns to the *Zeitschrift fur Analytische Chemie:* Weigh 0·6 grammes of yarn, and dry it at 100°, when determine the amount of moisture. Remove it to a dry vessel, and pour over it 20 cubic centimetres volume of a solution of 4 volumes parts of concentrated sulphuric acid to 1 volume of water, and, if possible, allow it to remain for twelve hours in this state, but under constant stirring. The wool is now again placed in the same amount of concentrated sulphuric acid, and after four or five hours' standing, all the cotton will be certainly dissolved. The liquid is next diluted with a triple quantity of water and equal quantity of alcohol, and filter direct through paper. The residue is washed with hot pure alcohol till it flows off colorless, and if the washing be continued with hot water until the acid reaction ceases, then the pure wool remains only very slightly colored. The latter is next dried to a temperature of 100°, and after a deduction of 2 per cent. is made, the result gives the pure sheep wool. This deduction is based on the fact that wool after being treated with sulphuric acid increases in weight by 2 per cent. For the calculation of the cotton, Bayer assumes with colored yarns 3·5 per cent. of coloring material.

SUBSTITUTE FOR OIL IN PREPARATION OF WOOL.

THE following mixture is said to have been found by M. J. Scharr an excellent substitute for oil in the preparation of wool and other industrial purposes: Gum Arabic and virgin resin, each 30 grammes; linseed, 85 grs.; olive oil, 145 grs.; oleine, 145 grs.; hempseed, 60 grs.; borax, 45 grs.; ammonia, 15 grs.; Castile soap, 345 grs.; American potash, 30 grs., and potato fecula, 75 grs., the whole to be boiled for an hour and a half. The quantities given above are sufficient for one gallon. The proportions may, however, it is said, be varied according to the nature of the wool to be treated, but no further particulars are given.

WALNUT PEELS FOR DYEING.

ALTHOUGH at the present time the utilization of waste products has been more or less developed in every branch of science and art, and has so resulted in converting a great many of the hidden gifts of nature into really practical useful application, still it is a patent fact that much is thrown away at the present day as useless waste which might otherwise be profitably utilized. For instance, we may refer to the outer green peels of walnuts, which peels have long been known to contain dyeing material, although they have not received the attention paid to them which they unquestionably deserve. These walnut peels contain a yellowish brown coloring material, which forms a very genuine dye-stuff in its application to woollen and cotton fabrics, and for these and other reasons walnut peels form, it is true, an article of commerce, but their intrinsic value is far too little known to raise these peels to an important staple of commerce. It would be well if this article were more utilized, the more so when we remember that, year after year, a large amount of money is sent to foreign countries for dye-stuffs which serve for similar purposes to those which walnut peels might be made to answer, if the latter were not left non-utilized. Dyes prepared from walnut peels are very genuine. Wool, if treated with these colors, requires no mordants to be subsequently applied, and wools dyed in this fashion receive a very soft touch, in contrast to those shaded with vitriol. The dyeing process with such peel dyes is as simple as it is cheap, for one quarter of an hour's boiling of the fabric with this dye-stuff is quite sufficient, and the shades so obtained from light to dark brownish tints are pleasing and very genuine. In many districts of Europe, these walnut peels may be had for nothing, which fact certainly speaks for the more extensive utilization of these products. For dye purposes the walnut peels may be kept either in a dry state until required for use, or they may be packed and damped in casks, by which latter method their coloring strength is increased.—*Das Deutsche Wollengewerbe.*

SPONTANEOUS COMBUSTION OF ZINC.

AT a recent meeting of the Liverpool Chemists Association, Mr. E. Davies, F.C.S., called attention to an important trial that had recently taken place respecting the shipment of some zinc powder, the ruling of the court certifying that it was of a combustible and dangerous nature. Mr. Davies explained that the zinc powder is metallic zinc in a very finely divided state, being produced in the process of zinc smelting. He had noticed in operating on small quantities with addition of water that a considerable elevation of temperature takes place, but not actual fire.

Mr. Thomas Williams, F.C.S., said that during long experience which he had had in the management of zinc works he frequently had noticed a spontaneous combustion of zinc powder. The usual circumstances under which this happened were—1st. When newly produced powder was inadvertently deposited in a damp situation. 2nd. The zinc powder, which is collected in sheet iron pipe condensers attached to the mouths of the retorts, on being emptied undergoes active combustion. When the best zinc ores are under operation the zinc sublimate is of remarkable purity. The condensation of zinc powder takes place in an atmosphere of carbonous oxide gas.

THE POTASH THEORY OF SCURVY.

THE discussion which has recently been carried on in the columns of *The Times* respecting the outbreak of scurvy on board the "Arctic" vessels has recalled to our notice an article published in this journal in 1867 (*Chemical News*, vol. xv., p. 37), in which we referred to the views of the late Baron Liebig and other high authorities, who held that the value of lime juice as an anti-scorbutic is due solely to the potash which it contains. It may serve a useful purpose if, says the *Chemical News*, we reproduce extracts from this article. At any rate they will show the importance of lime juice being tested by competent analysts:

"Lime juice is used in the English Navy and Merchant Service as an efficient anti-scorbutic. Amongst American seamen scurvy is almost unknown, and this immunity has been ascribed to the very general use of potatoes; whilst in France and Russia the rareness of this disease is similarly ascribed to the almost universal consumption of thin light wines as a beverage. Rice, which has been frequently proposed as a substitute for potatoes, has, however, been proved to be utterly valueless as an anti-scorbutic. Again, the evil effects of salt meat are notorious, but fresh beef alone is capable of preserving health for almost any time.

"These facts are found to agree perfectly with the potash theory of scurvy. The mineral constituents of lemon juice are found to be extremely rich in potash, containing, according to Mr. Witt, upwards of 44 per cent. of this alkali. There is an opinion that the juice of the lime (*citrus limetta*) is stronger and more acid than lemon juice, but in chemical constitution there is not much difference between the two. Fresh vegetables, as a rule, are rich in potash salts; potatoes, which may be placed at the head, containing no less than 51 per cent. in their ash, according to Way and Ogston, and 55 according to Griepenkerl. Grape juice, which may be considered as the representative of the light wines so largely used in the French and Russian marine, contains in its ash from 60 to 70 per cent. of potash, while the husks of grapes have an ash containing 37 per cent. Rice, however, contains only 20 per cent. in its ash.

"Dr. Garrod, who has examined various kinds of food in reference to this point, gives the actual amount of potash contained in different alimentary substances. From this we learn that—

One ounce of	rice	contains	0·005	gr. of potash.
"	lemon juice	"	0·852	"
"	boiled potato	"	1·875	"
"	raw beef	"	9·509	"
"	salt beef	"	0·394	"

"But without assuming that the active principle of these various anti-scorbutic foods is the potash which they contain, there is no doubt whatever that chemical analysis is abundantly able to show the quality of lime juice in an accurate and rapid manner. The constituents of lime juice are not many; the organic part contains citric acid, mucus, vegetable albumen, pectin, and sugar; whilst the inorganic constituents consist nearly half of potash, and the rest of the ordinary ingredients of the ash of plants. It is certain that most of these have no action as far as scurvy is concerned, and a little investigation could not fail to show whether the specific consisted of the potash or some other constituent. The work of the analyst would then be to see *generally* that

the article was in a state fit for food and likely to keep, and *specially* to see that the percentage of the active ingredient did not sink below a certain standard. Too much stress has been laid on the considerable time which it is supposed lime juice would take to analyze; and Dr. Leach has stated 'authoritatively that any juice may be safely pronounced good, bad, or indifferent, in *from twenty to thirty hours* after its receipt by the inspecting officer.' This is far longer than would be required. When once the appliances for such analyses were in working order, we do not hesitate to say that a skilful chemist would supply all the necessary information in a couple of hours.

"Assuming, as will most likely prove to be the case, that the potash salts are the specific agents against scurvy, chemical analysis is seen to be indispensable in the selection of anti-scorbutics for use on board ship. It then, however, becomes a question whether the active agent could not be stored and administered with far more economy, ease, and efficacy in the form of some convenient pharmaceutical preparation (such as the granulated effervescing citrate of potash) than when given through the exceedingly unscientific, clumsy, and ofttimes repulsive expedient of serving out lemon juice to the men. It might also be worth while to ascertain whether the desired end could not be secured by letting chloride of potassium partially replace chloride of sodium in the preservative processes to which the provisions are subjected.

"Whether every sample of lime juice should be separately examined before shipment, or whether Dr. Stone's suggestion be adopted of licensing a limited number of lime juice venders, and occasionally verifying the genuineness of their commodity by analysis, is a matter which need not at present be discussed."

TELEGRAPHING WITHOUT WIRES.

A YEAR or two ago a brief statement appeared in *The Telegrapher* and other journals in regard to the electrification of the island of St. Pierre, on which several of the cables of the Anglo-American Telegraph Company land. The phenomenon developed on this island has demonstrated the possibility of electrical communication between stations without wires—a problem which has been much discussed by electricians. The following details in regard to the electrical condition of the island, and the means adopted to get rid of the interference in the transmission of signals, will doubtless interest the reader.

The discovery was made by Mr. John Gott, the Electrician and Superintendent of the Anglo-American Company at St. Pierre. There are two offices on the island, one being used for repeating the cable business on the short cables between Sydney, C. B., and Placentia, N. F., and is operated by the Morse system, with a comparatively powerful battery; the other is the office at which the Brest and Duxbury cables terminate, and is furnished with very delicate instruments—the Brest cable, which is upwards of 2,500 miles long, being operated by Sir William Thomson's exceedingly sensitive dead beat mirror galvanometer; whilst on the Duxbury cable the same inventor's instrument, the siphon recorder (a description and drawing of which is found in Davis & Rae's handbook of electrical diagrams and connections), is used. The Brest instrument was found seriously affected by earth currents, which flowed in and out of the cable, interfering very much with the *true* currents or signals, and rendering it a most difficult task for the operator to decipher them accurately. The phenomenon is not an uncommon one, and the cause was attributed to the *ground* used at the office, and a spare insulated wire having been laid across the island, a distance of nearly three miles, a metal plate was connected to it and placed in the sea, and used in lieu of the *office ground*, the changes in the electrical potential of the sea being small and slow compared with those of the rocky soil of the island. This had the effect of removing the difficulty; but it was found, however, that part of the so-called earth currents had been due to the signals sent by the Morse operator into his wire, for when the recorder was put in circuit between the ground at the cable office and the sea ground—three miles distant—the messages sent by the Morse operator were clearly indicated—so clearly, in fact, that they were automatically recorded on the tape.

It must be clearly understood that the two offices were in no way connected, nor were they within some two hundred yards of each other; and yet messages sent at one office were distinctly read at the other, the only connection between the two being through the earth, and it is quite evident that they could be so read simultaneously at *many* offices in the same neighborhood. The explanation is clear enough. The potential of the ground at the two offices is alternately raised and lowered by the Morse battery. The potential of the sea remains almost, if not wholly unaffected by these, and the island thus acts like an immense Leyden jar, continually charged by the Morse battery and discharged, in part, through the short insulated line. Each time the Morse operator depressed his key, he not only sent a current into his cable but electrified the whole island, and this electrification was detected and indicated on the recorder. We quote the following from a British scientific journal on the subject.

"No similar experiment could be made in the neighborhood of a station from which many simultaneous signals were being sent, but it is perfectly clear that unless special precautions are taken at isolated stations, an inquisitive neighbor, owning a short insulated wire, might steal all messages without making any connection between his instrument and the cable or land line. Stealing messages by attaching an instrument to the line was a familiar incident in the American war, but now messages may be stolen with perfect secrecy by persons who nowhere come within a quarter of a mile of the line. Luckily the remedy is simple enough. All owners of important isolated stations should use earth plates at sea, and at sea only. This plan was devised by Mr. C. Varley, many years ago, to eliminate what we may term natural earth currents. Now it should be used to avoid the production of artificial earth currents, which may improperly be made use of."

There is no doubt this discovery has been much appreciated by scientists. We believe Mr. Gott is regarded as an excellent electrician, and it is said that on more than one occasion he has localized faults in cables within a few yards of the actual spot. We also believe that the practical success of the siphon recorder is mainly due to this gentleman, he having made many improvements in it since its introduction. Mr. Gott is not wholly unknown to telegraphers in New York. He visited this country during the past summer, and spent several days at the Centennial. He also paid a visit to both the Western Union and Atlantic and Pacific offices in this city, and was much interested in the quadruplex, Phelps motor, and automatic systems, and we have no doubt he saw many inventions in telegraphy that were entirely new to him.—*The Telegrapher.*

RESEARCHES ON THE RADIOMETER.

By Prof. PAUL VOLPICELLI.

1. ALL radiometers do not possess the same sensibility necessary for every experiment.

2. The most sensitive of the two which are in the physical museum of the Roman University shows that the freezing mixture of chloride of sodium and snow, applied to the upper hemisphere of the small globe, produces a rotation of the mill in the same direction in which it is produced by heat radiation, *i. e.*, with the white face of the small discs in advance.

3. If to this lowering of temperature be added a radiation of heat, the rotation of the apparatus is accelerated at the same time.

4. If the freezing mixture referred to be placed on the lower hemisphere of the same small globe, the apparatus will rotate with the absorbing, *i. e.*, the black faces in advance, and consequently in the direction contrary to that of the preceding experiment, *i. e.*, to the direction produced, if to the same lower hemisphere, radiant heat be applied.

5. If during the rotation produced by the application of the freezing mixture to the lower hemisphere of the small globe we cause radiant heat to strike the same globe, the apparatus will be brought to a stop; and, as soon as the source of heat is withdrawn, the rotation will immediately commence.

6. If the small globe is plunged entirely in a heated liquid, or even in a freezing mixture, the apparatus will remain at rest.

7. It should be noted that the freezing mixture applied to the upper hemisphere of the small globe produces a rotation in the direction opposite to that produced by the same mixture when applied to the lower hemisphere.

8. It has been stated that the radiometer in darkness remains at rest; but it should be remarked that if even in darkness it is affected by dark radiant heat, the apparatus will assume a rotatory movement; yet the instrument may remain at rest even when placed in a dark space.

9. The luminous rays of the full moon, focussed by means of a lens, do not cause rotation of the instrument.

10. If the radiation of the flame of a Locatelli lamp is caused to traverse several plates of perfectly transparent glass, it will be seen by the number of turns of the instrument that the law of De la Roche is verified regarding the absorption of radiant heat through these plates, however many they may be. I have been able by this means to diminish the radiant heat to such an extent as to cause the rotation of the radiometer to cease, although the light of the same radiation was increased by means of a lens.

11. The same radiation, that, viz., produced by Locatelli's lamp, by traversing a saturated but perfectly transparent solution of alum, before reaching the radiometer, did not set it in motion, although the radiant light was but little diminished; and the same is the case when the light is increased.

12. It would appear at present that the rotation of the radiometer depends on radiant heat and not on the luminous rays.

13. It appears also that the mechanical cause of the rotation of the radiometer consists in the motion of the molecules of very rarefied gas in the small globe, which is in accordance with the opinion of modern thermodynamics.—*Nature.*

RECENT RADIOMETER EXPERIMENTS.

AT a recent meeting of the Physical Society, London, Professor G. C. Foster, F.R.S., President, in the chair, Mr. Crookes described some of the most recent results he has obtained in his experiments on the radiometer, and exhibited many beautiful forms of the apparatus, most of which have been devised with a view to decide on the correct theory of the instrument. He commenced by describing the arrangement he has used for some time past in studying the resistance offered by air and other gases to the rotation of a mica disk. It consists of a mica plate suspended by a fibre of glass, and enclosed in a chamber which can be exhausted to any required extent. A mirror is attached to the mica, and the movement of a luminous point reflected from it shows that the decreasing swings form a logarithmic curve, and Mr. Crookes takes the logarithms of the decrements of the swings as a measure of the viscosity of the gas under examination. From the normal atmospheric pressure to the best vacuum which can be obtained by the ordinary air-pump this decrement remains nearly constant, and these experiments have been carried on in vacua of remarkable perfectness, the highest exhaustion obtained being represented by 1 millimetre on a scale of 10 miles, a point which was attained by means of a Sprengel pump, with improvements by Mr. Gimingham, and measured by a McLeod gauge. If the "logarithmic decrement" be represented by 125 at a pressure of 760 m.m., it is not reduced to 70 until the pressure has been reduced to 35 millionths of an atmosphere, and at this point the action of light on a radiometer is at a maximum. On continuing the exhaustion this influence is found to decrease, and Mr. Crookes concludes that in a perfect vacuum the log. dec. would not be zero, but about 0·01; that is, a mica plate would not continue to oscillate forever, a fact probably due to the viscosity of the glass fibre. About fifteen different forms of the radiometer were exhibited, and their inventor has satisfied himself that the theory of their action proposed by Mr. G. Johnstone Stoney is the only one capable of completely accounting for their action, and he considers it to be in all probability the correct one. By means of a double radiometer, consisting of two globes of different diameters, and having a wide opening between them, and provided with a four-armed fly which can be made to rotate in either bulb, it has been shown that, other things being equal, the velocity of rotation decreases as we increase the diameter of the bulb. As, on the molecular-movement theory, the rotation is due to a throwing off of particles from the blackened surface of the mica, it follows that, if a piece of transparent mica be attached to each fly in front of the blackened surface, the rotation will take place in the opposite direction, and this proved on experiment to be the case. And, further, when such a plate is placed on either side of the vanes, the motion of the instrument is almost entirely stopped. As these facts can be explained on the "molecular movement" or the "evaporation and condensation" theory, Mr. Crookes arranged a radiometer having four transparent mica vanes, and mounted in a rather large bulb. At the side of the bulb a plate of mica, blackened on one side, is so fixed in a vertical plane that the vanes can pass, and when light shines on this fixed plate the fly is found to rotate, a fact which in itself disproves the latter theory. Many other curious forms were exhibited, in some of which the vanes were cup-shaped, as Mr. Crookes has found these to act as well as the ordinary form, a convex surface acting as though it were blackened. In conclusion, he exhibited a photometric four-vaned radiometer, in which the fly was attached to a small magnetic needle, and this might be so checked by an external magnet that the strongest light would be incapable of causing the needle and vanes to make a half rotation. If the circumference of the globe be graduated, and the apparatus be brought within the influence of a source of light, the angle to which the needle is deflected will be a direct measure of the intensity of the light, and Mr. Crookes showed that by a simple arrangement such an instrument might be rendered self-recording.

Prof. Dewar exhibited a simple electrometer which he has designed, founded on the discovery of Leipman that the capillary constant is not really independent of the temperature or the condition of the surface, but is a function of the electromotive force. If a capillary tube be immersed in mercury, and dilute sulphuric acid be placed in the tube above the mercury, and a current from a Daniel's cell be so passed through the liquids that the mercury forms the negative pole, the column will be depressed to an extent dependent on the diameter of the tube. In making an electrometer Prof. Dewar has increased the sensitiveness by connecting two vessels of mercury by means of a horizontal glass tube filled with the metal, except that it contains a bubble of dilute acid. The tube must have an internal diameter of 2 millimetres, and it is essential that it be perfectly clean, uniform in diameter, and horizontal. The instruments exhibited were constructed by Messrs. Tisley & Spiller, and Prof. Dewar showed that it is possible by means of them to measure an electromotive force equal to $\frac{1}{10000}$th of a Daniel's cell; forces capable of decomposing water must be measured by causing two currents to act against each other. The index bubble is brought to zero by uniting the mercury cups by a wire. The apparatus is very convenient, as it requires no preparation, and is extremely simple in its action. He then showed an instrument, arranged by Mr. Tisley, for producing a current by the dropping of mercury from a small orifice into dilute sulphuric acid. If the vessels containing the mercury and the sulphuric acid be connected by a wire a current is found to traverse it, and Prof. Dewar explained how the electrolysis of water might be effected by this means. He then exhibited a delicate manometer suitable for measuring very slight variations of pressure, and he illustrated the use of it for proving Laplace's law that the internal pressure, multiplied by the diameter of a soap-bubble, is constant. It consists of a U-tube, one arm of which is about 15 inches long, and is bent horizontally, and levelled with great care. If the shorter arm be connected with a tube on which a bubble has been blown, and the diameter of the bubble be varied, the position of the extremity of the alcohol column will be found to vary in accordance with the above law.

SOCIETY OF TELEGRAPH ENGINEERS.

THE fifth *conversazione* of the Society of Telegraph Engineers, London, was lately given at Willis' Rooms, St. James', and was in every respect a splendid success. The president for 1877 is Prof. Abel, F. R. S., and the four vice-presidents, Mr. B. Preece, Professor Carey Foster, F. R. S., Major Bateman Champani, and Mr. Carl Siemens. The *conversazione* owed much of its success to the able and judicious management of Mr. Sivewright, the acting secretary, thanks to whose attention in directing the preliminary arrangements the various exhibits were thoroughly representative of the whole subject of telegraphic engineering, as they included apparatus and instruments for all purposes connected with the laying, recovery, testing and repair of telegraphic cables, and very numerous applications of electricity to various useful objects in daily life. Some of the exhibits, and of these there were several, were of a purely scientific character, and as such excited great interest, without professing to have any practical bearing on the main object of the gathering.

NEW MARINE COMPASS.

Of the immense number of instruments and inventions exhibited, the following were among the more striking: Sir William Thompson sent his new marine compass, by means of which the errors resulting from local attraction in iron ships are entirely eliminated, and the navigator is rendered so far the more independent of false indications.

Mr. Robert Sabine exhibited the apparatus by which the late Sir Charles Wheatstone produced motion in a globule of mercury enclosed in a glass tube by simultaneously producing oxidation at one end of its surface and deoxidation at the opposite end. Sir C. Wheatstone devised a telegraph on this principle, and was engaged in researches on the subject in France at the time of his death.

Mr. Sabine also exhibited an electric arrangement by which it is possible to determine so small an interval of time as the ten-millionth part of a second. It is known from mechanical considerations that impact is a great pressure of short duration—so short as to appear to the eye utterly inappreciable. When an anvil is struck by a heavy hammer, for instance, each body penetrates into the other, moving through a minute space until the whole force of the blow is expended, and the two bodies in contact have reached the extreme of compression. Then the force of elasticity is called into action, and this separates the two. That a very small interval of time, though still a finite one, is occupied by impact is proved by this apparatus, and its duration is measured.

A very delicate electrometer was exhibited by Professor Dewar, of Cambridge. It consists of two vessels containing mercury, which communicate by means of a horizontal glass tube, into which the mercury from each cup flows on either end. The two columns of mercury are separated by an air-bubble, which moves along the tube under the influence of two charges of electricity passed into the reservoirs of mercury.

The Electric Exchanges Company exhibited some very simple and useful apparatus, with which every large and important building, and, if possible, every house, should be supplied, as by means of it an effectual safeguard against fire and burglars is provided. Only a single electric wire is used. Should a fire break out in a house, say, in the dead of night, the heated air acts upon a small piece of metal contained in the apparatus, and by the expansion of this an electric circuit is completed, and immediately a Morse telegraph is set in motion, with the result of informing the nearest fire station of the address. On a burglar's forcing an entry into a house the police receive a similar intimation. (These devices have been in use in New York for several years.) By another of these contrivances a policeman, instead of springing his rattle, can, by merely turning a key, inform the station that he wants assistance at a given spot.

Mr. Spagnoletti, telegraphic engineer to the Metropolitan and Great Western Companies, exhibited a great variety of very simple and effective apparatus for the safe working of lines of railway. First among these must be mentioned the electric signal, which may be worked at any distance by merely touching a key. This liberates a detent and an elec-

tro-magnet draws the signal down. Touching another key raises the signal by means of the same electro-magnet.

Another very useful contrivance is the lightning proof needle. Lightning acts injuriously on the signals sent by needle instruments in four different ways. It either weakens the signals or neutralizes them, rendering them therefore useless, or reverses them, or it fuses the whole apparatus. Of these four heads of disorganization, this instrument completely obviates the first three. It is largely used on most of the principal lines of the kingdom, and works very satisfactorily.

Another useful invention of Mr. Spagnoletti's is a telltale, which warns a signal attendant in his hut that a particular signal lamp has gone out, and requires attention. This is effected simply by the introduction of a piece of metal into the lamp case. As long as the lamp is burning, and the temperature therefrom high, the dilation of the metal completes an electric circuit, and the telltale shows the word "in." When the lamp has gone out, and the temperature has fallen, the contraction of the metal opens the circuit and the word "out" appears on the face of the instrument.

Wray's thermo electric batteries attracted much attention also. They are very simple, and for many purposes would be both efficient and economical.

The electric telephone, a very curious instrument, was exhibited on the same table. Its object, as its name implies, is to convey sounds to a distance by means of electricity. In the apparatus exhibited, the sound of the voice sends atmospheric undulations against a stretched membrane, which thereby receives a rapid and irregular succession of vibrations. At its centre a small slip of metal is affixed to it which is in connection with a battery. At the end of each oscillation contact is completed, and the circuit closed. The membrane immediately recedes, and is again sent forward. Thus the current passes and is suddenly checked, according as the waves of sound break upon the surface of the membrane. At the receiving station the core of an electro-magnet is thrown into a corresponding state of rapid movement, and sounds are emitted, which, being increased in volume by the ordinary means for that purpose, are rendered plainly audible at the distant station.

Sir George B. Airy, the Astronomer Royal, exhibited the record of galvanic and magnetic currents passing through the earth, as taken at Greenwich Observatory. These plates were never before exhibited, and represent a very careful and useful work which has been carried on for some time with a view of tracing out these currents and showing their connection.

Jamieson's improved grapnel for recovering lost cables was among the apparatus exhibited. A great fault of previous grapnels was that they caught in ledges of rock, when their claws broke away, and they would then pass over the cable, and the vessel would have to return and pass over the same track again, thus losing much time. The new instrument is so contrived that, upon coming into contact with a resisting object, the claw opens out by moving on a strong pivot, and when the cable is reached it is firmly caught by the claws, and may be hauled on board at once. The instrument is being made by Hoe & Co.

Among the scientific apparatus exhibited were some very interesting ones by Mr. Ladd. Faraday's beautiful experiment of polarizing light by electro-magnetization was shown by a very fine apparatus for the purpose. The light from a strong lamp passes through a Nicol prism along a glass bar, and again through an analyzing prism into the eye, and the charge being passed through the coil surrounding the magnet, the change of tint showed that the light had been polarized or twisted.

Another instrument, exhibited by Mr. Ladd, was much admired, though it was a mere magnetic toy. It consists of a strong horse-shoe magnet, mounted vertically on a stand. Inside the terminal are two thin disks of iron in contact with the poles. They are of bright metal, and have a bevelled edge all round their figure, which is a long closed curve. The armature is a steel arbor, upon which a brass wheel is mounted. The arbor being laid horizontally upon the edges of the disks, and the instrument held obliquely, the wheel rolls along the edges, and is brought back by attraction on the other side. By jerking the instrument at the proper intervals, the wheel ascends and descends continually like a bandalor.

Mr. Horatio Yeates' voltaic gas lighter was also exhibited. This is a small battery of low power, the current of which is set in motion by a touch of the finger. A piece of fine platinum wire, which lies in the circuit under a bell-shaped covering, is thereby heated to redness, and on a stream of gas being directed upon it it is immediately inflamed.

One of the most popular objects in the whole exhibition, however, was that of the electric pen and autographic press. It was exhibited by the Electric Writing Company, and many specimens of writing performed with the pen were given away. By means of a small battery at the top of the pen a needle pierces the paper with fine holes at the rate of 8,000 per minute. Impressions are obtained by passing an inked roller over the pierced paper or "stencil," the ink being forced through the fine holes to the paper below. 2,000 can be taken from one stencil at the rate of 360 per hour. The battery is about the size of a crown piece, and it did its work most perfectly. (This is the invention of Mr. Edison, of Newark, N. J.)

Mr. Browning, of the Strand, exhibited a very fine spectroscope, and by means of it, and the aid of a powerful induction coil, the spectrum of iron. He exhibited, also, some fine binocular microscopes, in which the results of deep sea dredgings in various parts of the world were very beautifully shown.

The Pneumatic Dispatch Company put in an appearance with their apparatus, which worked very perfectly. In this system the written message is placed in a cylindrical case, which is put into a tube, by a lateral opening, and then shut in. The case may be sent in either direction.

In a darkened room adjoining the great saloon in which the *conversazione* was held, Mr. Apps, of the Strand, gave a grand display with rich combinations of Geissler's tubes, using his power induction coils for the production of their gorgeous effects.

The visitors were very numerous, so much so that the principal stands were at times very difficult of access.—*The Engineering and Building Times.*

THE project of amalgamating the Anglo-American and the Direct Cables, in order to put up the prices, is not encouraged by the U. S. Government. The landing permission given to the Direct Company forbids. The President is of the opinion that the control of the United States over its jurisdictional waters extends to the right of discontinuing and preventing their use by a cable whose proprietors may violate any of the conditions on which the Government has, by quiescence or silent permission, allowed its landing, as well as to the resistance and prohibition of an original landing.

THE SIPHON TELEGRAPH RECORDER.

FOR some time after the introduction of submarine telegraphy Sir William Thomson's mirror galvanometer was the only instrument delicate enough to receive the signals transmitted through a long cable. The spot of light reflected from the mirror moves over the scale and indicates every change of current in the cable. The clerks by degrees learn to interpret the motions of the spot of light, and are able to read the signals sent. The signals, however, must be read at the instant of arrival, and the clerk has no way of correcting what he receives except by having the signals repeated from the distant end.

The Siphon Recorder was devised, more recently by Sir William Thomson, for the purpose of receiving and recording the signals transmitted through a submarine cable; though it may also be used for receiving signals sent along a land line. It actually draws on paper the curves corresponding to the changes of current which pass through the line. Thus a permanent record is made of every signal that is sent, and not only can the clerk be sure that he reads the signals correctly, but also any mistakes in transmission can be traced to the station and person where they occur.

The Recorder consists of a powerful electro-magnet, between the poles of which a coil of fine insulated wire is delicately suspended, so as to be able to move round a vertical axis. The current from the cable is made to pass through this coil of wire. When a current passes through a coil suspended between the poles of a magnet, the coil tends to take up a position with its plane at right angles to the line joining the poles. There are two weights suspended from the bottom of the coil, which, when no current is passing, keep the plane of the coil in the line joining the poles of the magnet. When a positive current is passing, the coil tends to turn round a vertical axis in one direction, and, when a negative current is passing, it tends to turn round in the opposite direction.

The coil is connected by means of silk fibres with a very fine glass siphon, suspended so that one end dips into a metal box containing ink, and the other end hangs down nearly touching a paper ribbon. The motion of the coil is thus transmitted to the glass siphon. The metal box containing the ink is insulated and is electrified by means of an electrostatic induction machine while the paper is connected with the earth. The ink being electrified is drawn from the point of the siphon and spurted out in small drops on the paper. When no current is passing they form a straight line on the paper as it is drawn past the end of the siphon; but when a current passes through the coil, it being deflected, draws the siphon to one side, and the line on the paper is no longer straight, but indicates the deflections of the coil. The well-known Morse alphabet is used with the recorder. A deflection of the siphon-point to one side corresponds to a dot, and one to the opposite side to a dash.—*Nature.*

ASTRONOMY.

ROYAL ASTRONOMICAL SOCIETY, London. December. Dr. Huggins, President, in the chair. Father Perry gave an account of some experiments by M. André, of the Paris Observatory, on irradiation in telescopes, and its influence in producing the appearance of a black drop or ligament in transits of Mercury and Venus. The results appeared to agree with those deduced by former observers from occultations of stars at the dark limb of the moon, and from eclipses of the sun, as well as from measures of the spurious disks of stars. Dr. Huggins exhibited a drawing made from a photograph of the spectrum of the bright star Vega, which he had succeeded, after many trials, in obtaining. The spectrum extended from the Fraunhofer line G in the blue to N in the ultra-violet, and showed five or six strong, well-defined lines which could be compared very accurately with those in the solar spectrum, the photographic plate having been left in the instrument all night and exposed on the sun the next morning, using a different part of the slit. In this way a photograph of the solar spectrum was obtained above that of the star, and a comparison ot the two rendered very easy. Dr. Huggins has devoted much time to this work since his earliest attempts in 1866, and has now obtained most successful results, which are of the more importance as the greater part of the spectrum on the photograph is beyond the range visible to the eye.—A paper by Mr. Stone, "On the black drop in the late transit of Venus," was then read, the author's main point being that the black drop was really seen by several skilled observers, and in particular by M. Janssen, although they had described it in different terms, leading some writers to the conclusion that this appearance was entirely due to want of skill in the observer, or to defect in his instrument.—Mr. Christie described some photometric observations of the gradation of light on Venus, the result being that the middle of the disk appeared to be about seven times as bright as the limb, which would support Mr. Brett's conclusion that the surface of Venus is smooth and reflects light specularly. Mr. Nelson pointed out that there would be a slight gradation towards the limb, even with a tolerably rough surface, though it would not approach that found by the observations of the preceding speaker.—After this, Mr. Mattieu Williams read a paper criticising some remarks of Prof. Langley in a paper read at the last meeting, on the effect of sun-spots on climate; and Mr. Marth exhibited a diagram of the orbit of the remarkable binary star α Centauri, urging strongly on astronomers in the southern hemisphere the importance of making repeated observations of this double star about this time, at intervals of a fortnight or less, with a view to an accurate determination of its period, as the two components are now in conjunction. It appeared that the orbit of this interesting binary rests almost entirely on the measurements of Jacob and Powell, at Madras, and the exact length of period is of the more importance as the parallax is so well determined (this being, so far as is known, the nearest fixed star) that the mass of the revolving system could then be found very accurately. There are now so many observatories with large telescopes in the southern hemisphere that there ought to be no difficulty in securing a large number of observations.—*Academy.*

VOLCANIC OCEAN DISTRIBUTION.

AT a recent meeting of the Royal Society of Edinburgh, a paper was read by Mr. John Murray of the Challenger Expedition, "On the distribution of volcanic *débris* over the floor of the ocean—its character, source, and some of the products of its disintegration and decomposition." Having in the outset described the instruments with which specimens of the ocean floor were brought to the surface, he stated that pumice stone was the volcanic deposit which was most frequently met with in ocean depths. In no single instance had they trawled successfully in any deep sea without getting numbers of these stones; or if these were an exception, it was in the North Atlantic. The pumice stones were more or less covered up by diatoms or foraminiferæ, and the majority of them had a rolled or rounded appearance as if carried down by streams. They contained traces of felspar, hornblende, and other volcanic minerals, and some were coated with peroxide of manganese. Most likely these pumice stones were formed in the air; the great majority had probably fallen on the land, being subsequently washed or floated into the sea by rains or rivers, and after floating about a long time had become waterlogged and sunk. All the pumice stones might, however, not be of recent origin, for both in South America and New Zealand rivers were known to cut through large deposits of the stones and carry them seawards. The only place where they might require a submarine eruption to account for the *débris* found, was off the coast of South America, in the South Pacific. The materials brought down by rivers from the coasts, appeared to be deposited in the ocean bed within 200 miles from land, although ice borne detritus was found in the North Atlantic, down as far as the fortieth parallel. Again, they had the dust from deserts, carried by the winds till they fell on and sunk to the bottom of the ocean. Minute animals extracted from the water of the ocean carbonate of lime to form their shells, and the animals dying, the shells fell to the bottom, and composed the Globigerina, the Radiolarian, the Diatom, and the Pteropod ooze. Lastly he noticed the manganese deposits, which consisted of nodules—incrustations or depositions—the most frequent being the nodular forms in the deep seas far from land, and brown incrustations in shallow water; as also the discovery of iron particles in deep ocean beds. The conclusion to which he had been led by these observations were (1) that volcanic *débris*, either in the form of pumice stone, ashes, or ejected fragments, are universally distributed in ocean deposits; (2) that pumice stones are continually being carried into the sea by rivers and rains, and are constantly floating over the surface of the ocean far from land; (3) that the clayey matter or deposit far from land is principally derived from the decomposition of felspar or fragmental volcanic rocks, though in the trade wind region of the North Atlantic the dust of the Sahara contributes much material for clay; (4) that the red earth of Bermuda, the Bahamas, Jamaica, and other limestone countries is most probably originally derived from the decomposition of pumice stone when these limestones were in the process of formation; (5) that the peroxide of manganese is probably a secondary product of the volcanic rocks and minerals present in the areas where the nodules of manganese are formed; (6) that there are many minute particles of native iron in deposits far from land; that some of these particles are little spherules; that these last as well as some other spherules, which are magnetic, have probably a cosmic origin; (7) that the peroxide of manganese depositions in the deep sea are different in structure and composition from known ores of manganese; and (8) that we do not appear to have equivalents of the rocks now forming in the deep sea far from land in the geologic series. A hearty vote of thanks was accorded to Mr. Murray for his paper, which was illustrated by numerous boxes of specimens of organic, volcanic, and mineral dredgings from depths as great as three miles.

THE GROWTH OF PLANTS.

By W. B. HEMSLEY.

USUALLY, in plants, the embryo retains its germinating power much longer than in animals, and in this state it will bear a much wider range of temperature than the actively growing plant. Of this fact we have recently received a most remarkable confirmation by Dr. Belgrave Ninnis, one of the members of the Arctic Expedition, who succeeded in growing wheat from seeds left exposed in the Arctic regions, four years previously, by the *Polaris* party. Another instance may be given. The mature or flowering bulbs of the beautiful Cape *gladioli* are killed by little frost, whereas the tiny bulblets formed around them will withstand our winters unharmed on the surface of the ground, and eventually develop into flowering bulbs. Here, then, we have a wonderful provision for the perpetuation of a plant. It is also worthy of note that the seeds of most of our native plants lie dormant in the ground until the warmer temperature of spring stimulates them into growth. Sometimes, on the other hand, unusually warm weather in the autumn or early winter will cause some of the seeds to germinate, but not to make sufficient growth to withstand the cold of winter. The conditions subject to which seed will germinate are heat and moisture, varying in degree and quantity according to the species. Different species present widely diverse constitutions.

De Candolle, the celebrated French botanist, has recently made a number of experiments to determine the temperatures most favorable to the germination and development of the seeds of various plants, as well as the sum totals of heat required by different species to attain maturity. The common mustard, *Sinapis alba*, will germinate at, or a little above, 32° Fahr. in seventeen days, and in a shorter period as the temperature is increased up to 70°, at which temperature it will germinate in less than twenty-four hours. Above this temperature, each increment was more and more unfavorable, until at 104° not a single seed germinated.

Taking the melon as an example of a tropical type, he found the lowest temperature at which it would germinate to be about 61·5; but from 66° to 75° was the most favorable heat, and above 82° the temperature appeared to act detrimentally. *Sesamum orientale* germinated in ten and a half hours, at a heat of 104° to 105°. Number 3,935 in the Loan Collection is an apparatus employed for various purposes, in which a constantly uniform temperature is required, among others, for determining the germinating power of agricultural seeds.

When seed is committed to the ground under suitable conditions of heat and moisture, the contents of the cells undergo certain chemical changes, cell division takes place, and roots and leaves are formed which absorb and keep up the supply of nutrient substances required. The main point to remember is that every growth is the result of previously stored up materials. This may be proved by causing seeds to germinate in a medium, from which they can derive no nourishment beyond that stored up in themselves. Large trees, too, will sometimes continue to grow for some time after being felled; that is, until the supply of food is exhausted. So far, only the mode in which the substance or frame of a plant is built up and increases has been considered; it now remains to point out where growth takes place, and the manner in which our trees increase in height and size of trunk.

There is an essential difference between the growth of plants and animals, taking oak or any other of our common trees as a type; and a knowledge of this difference would

have prevented an enthusiastic American telling us that, on returning to his native place after many years absence, he espied high up on the trunk of a tree the initials he had cut when a boy some few feet from the ground. In animals the limbs grow throughout their entire length, and not merely at the extremities, until the individual has attained its full size; consequently, in the human species, the knees may be as far from the feet at the age of eighteen years as the head was at the age of as many months.

HOW TREES GROW.

Without asserting that the trunks of trees do not grow at all throughout their entire length, it may be safely stated that it is so slight as to be inappreciable, and any person returning to a tree known to him only in his childhood would be more struck with the apparent lowness of the branches, which in his boyish days required some climbing to reach. It is true that a given spot on the trunk of a tree may be a little higher ten years hence than it is to-day, though this may be due to some other cause than lengthening out. Indeed, this has been observed of trees growing in crevices of hard rocks, in consequence of the increase in the diameter of the principal roots.

If we plant an acorn, and occasionally examine the tree springing from it, we shall, as early as the second year, become aware of two kinds of growth, an apical and a lateral. During the growing season of the first year a single stem will make its appearance, with the leaves at first very close together, the spaces between them increase gradually in length, until growth ceases and the leaves fall off. The following spring another period of growth commences with the result, under favorable circumstances, that the stem increases in height by a second shoot (or continuation of the first), which lengthens, telescope-like, just as the first year's shoot did. With regard to the first year's growth, there will be an increase in its diameter but not in its height, and this holds good for each successive growth to the ultimate branchlets of the largest oak or beech. This fact is so easily confirmed that further comment would be superfluous.

Briefly, the trees of our woods exhibit two apparently different but essentially the same kinds of growth—new shoots elongating throughout their whole length, and new layers of wood on previous years' shoots, branches, and trunks, which merely add to their diameter. These additional growths appear as successive slender cones, each one adding to the length and size of the axis formed by them collectively. In most of our trees they appear as rings in a cross section, the number of which indicates the age of the tree at the height or part where the section is made. Hence, if the real age of a tree be required, the section must be taken from near the ground.

In palms the mode of growth is quite different; the trunk scarcely increases in size, but merely grows taller. Here the hardest wood is near the circumference of the trunk, just the contrary to what obtains in the oak.

RATE OF GROWTH.

A few words now respecting the rate of growth, and the force exerted by the growing tissues of plants. Two or three ingenious contrivances for registering the velocity of the growth of the plants are exhibited at South Kensington. In principle they are essentially the same. A thread is attached to the tip of the growing stem, and passed over a pulley and kept stretched by a small weight at the other end. As the shoot lengthens the weight descends, and a long index on the revolving wheel of the pulley describes an arc of sufficiently large dimensions for purposes of observation. How far growth (mere extension) and the formation of cells coincide it is difficult to say; and perhaps cell division is least active during the actual period that extension takes place. But even if there are alterations of cell formation and cell distension, the formation of cells is incredibly rapid in some plants at certain seasons. Some trees, such as the yew, grow very slowly; whilst others, some of the poplars, for example, attain the dimensions of large trees in thirty or forty years. Among sub-tropical and tropical plants we have many instances of much more rapid growth; thus some of the bamboo will attain a height of sixty or seventy feet in a less number of days, and the lofty flower shafts, *Agave americana*, spring up no less rapidly.

The expansive force of growing vegetable tissue is something marvellous. Even the apparently soft cellular fungi will lift enormous weights; and almost every reader must be familiar with some records of their displacing huge flagstones or bursting the arches of cellars. About two years ago, Mr. W. S. Clarke, president of the State Agricultural College of Massachusetts, assisted by a number of the officers and students of the college, conducted a series of experiments to ascertain the expansive force of vegetable tissue. It would occupy too much space to describe the experiments in detail, and the apparatus employed; but the results may be summarized in a few words. The plant employed for the purpose was the mammoth pumpkin, *Cucurbita maxima*. The fruit was the part confined to test the force. The seed was planted on July 1st, and the plant grew with such extraordinary rapidity that by August 1st the first female flower was artificially impregnated. The young pumpkin immediately began to enlarge, and on the 17th it measured 27 inches in circumference. It was then confined, and connected with an apparatus for measuring its lifting power. The weight lifted increased from 60 lbs. on August 21st to 500 lbs. on August 31st. By the end of September it raised 2,015 lbs., and on October 24th the weight was increased to 4,120 lbs. The last weight was 5,000 lbs., but this was not clearly raised, though it was carried ten days, on account of the breaking of the apparatus. The root system of this pumpkin plant was something extraordinary. After carefully washing away the earth from it, it was measured in all its ramifications; the entire length being calculated at 15 miles. It was also estimated that 50,000 feet of roots must have been produced at the rate of 1,000 feet or more per day. A second plant of the pumpkin in the same bed was cut off close to the ground when eight weeks old, and attached to a mercurial gauge to measure the pressure of the sap. The maximum force attained was equal to a column of water 48·51 feet high. Numerous other experiments in the same branch of inquiry might be quoted, but they reveal only the same phenomena in different plants.—*Journal of the Society of Arts.*

PROPAGATING GRAPEVINES.

A SUBSCRIBER to the *Country Gentleman*, who had noticed the fact that in making its annual awards the Massachusetts Horticultural Society mentioned the very large clusters of Concord grapes grown by N. Blanchard, of East Stoughton, Mass., wrote to him to obtain some instruction in producing vines which would yield bunches of fruit weighing over a pound each. Mr. Blanchard's reply is as follows:

In reply I have to say that nearly all of my vines were started by layers of previous one year's growth from vines that had never fruited. I grow a single cane this year, and the next cut it off to about 4 feet, cut off the side branches or laterals, open a trunk 6 inches in depth, lay the cane down and fasten horizontally and leave the trench open. When the buds push and have grown 3 or 4 inches, fill in with best earth enough to cover the bases of the buds, and as the shoots grow, keep tied to a stake, and keep filling in until the trench is full. I select usually three shoots on a cane of 4 feet, and rub off all others. The three left will give us the best possible and durable vines that I know of. That has been my experience.

I have used cuttings of some new sorts where the wood has been scarce, but it has never been satisfactory. I do not doubt but good plants may be so gotten, but I much prefer layers as described. With cuttings, my method has been to take, when pruning the vines in November, wood thoroughly ripened from near the base of starting, with three buds on a cutting. Pare off smoothly close up to the lower bud, leave about one inch of wood above the upper bud. When enough have been prepared, tie the bundle, put them in the ground or some moist place where they will not freeze and thaw. When the ground will do to work in the spring, open a trench 6 or 8 inches deep, on rich soil and lay the cuttings on an angle of 45°, and 8 or 10 inches apart, taking care to pack closely around the lower bud, and leaving the upper one at the surface after the ground has settled. The lower and middle buds will make roots, and if grown strongly they will do the first season to transplant by lifting carefully and cutting away all soft or spongy roots, and reducing the top to 6 or 8 inches. In no case should more than one shoot be allowed to grow the two subsequent years, and this must be kept tied to an upright stake. N. B.

CULTURE OF GRAPES.

THE report of the Fruit Committee of the Montreal Horticultural Society gives the following rules for the management of grapes in that climate:

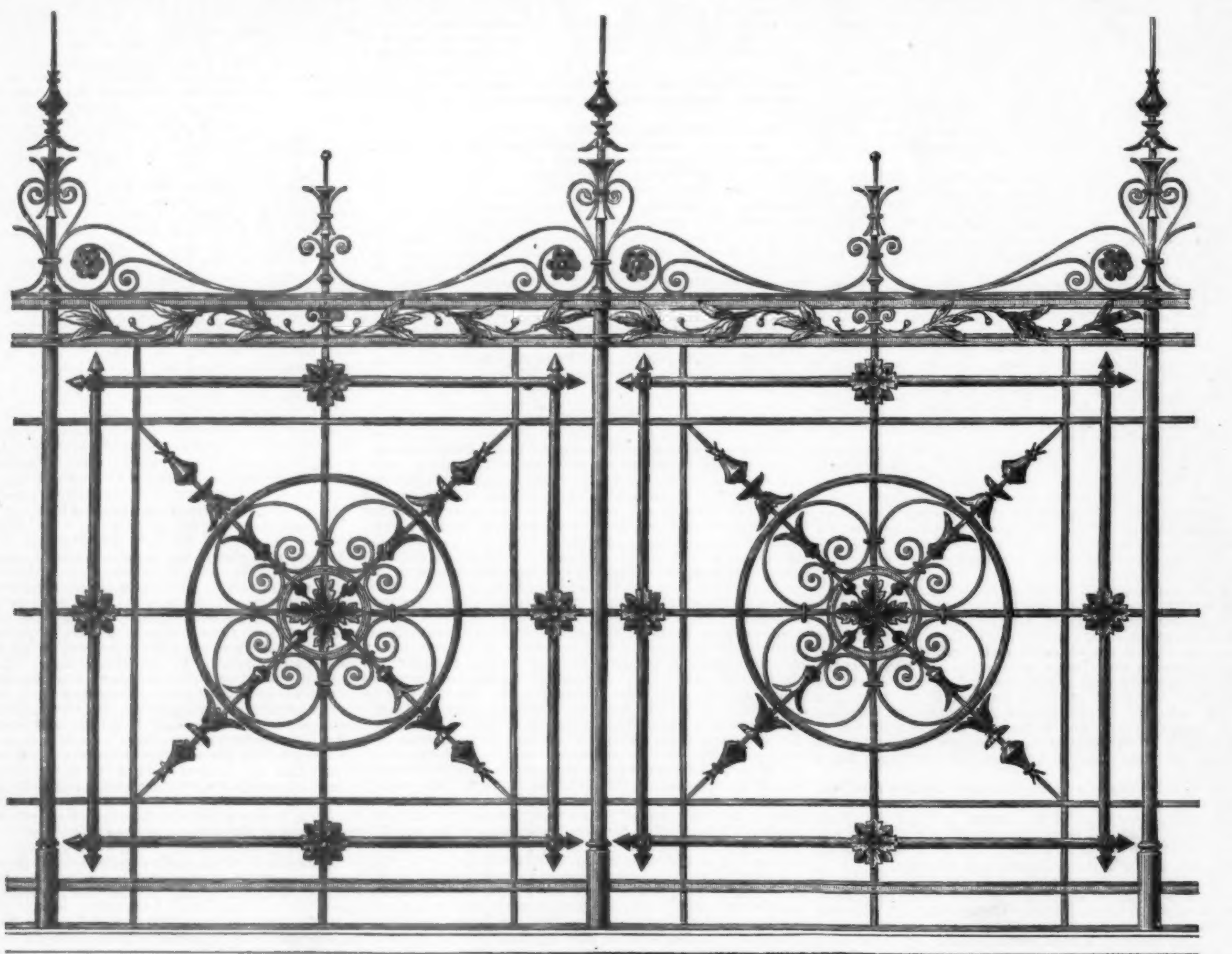
1st. Ground thoroughly underdrained.

2d. Well pulverized garden soil; the richer the better.

3d. A southern exposure, where the full benefit of the morning sun may be had. Fruit will ripen at least a week sooner, if grown against a wall or fence. Protection, by means of a belt of trees or fence, against the cold north and east winds, is a great safeguard in our northern climate.

4th. A covering of from 4 to 6 inches of earth or other material in winter.

5th. Constant but not severe pruning; a certain amount of foliage being requisite to bring fruit to perfection.



WROUGHT IRON RAILING FROM THE REUTER MONUMENT, EISENACH. DESIGN OF KYLLMANN AND HEYDEN. (*From the Workshop.*)